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# **AERONAUTICAL ENGINEERING**

## **A Continuing Bibliography**

### **Supplement 137**

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in June 1981 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA)*.

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# INTRODUCTION

Under the terms of an interagency agreement with the Federal Aviation Administration this publication has been prepared by the National Aeronautics and Space Administration for the joint use of both agencies and the scientific and technical community concerned with the field of aeronautical engineering. The first issue of this bibliography was published in September 1970 and the first supplement in January 1971. Since that time, monthly supplements have been issued.

This supplement to *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 483 reports, journal articles, and other documents originally announced in June 1981 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA)*.

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged in two major sections, *IAA Entries* and *STAR Entries*, in that order. The citations, and abstracts when available, are reproduced exactly as they appeared originally in *IAA* and *STAR*, including the original accession numbers from the respective announcement journals. This procedure, which saves time and money, accounts for the slight variation in citation appearances.

Three indexes -- subject, personal author, and contract number -- are included.

An annual cumulative index will be published.

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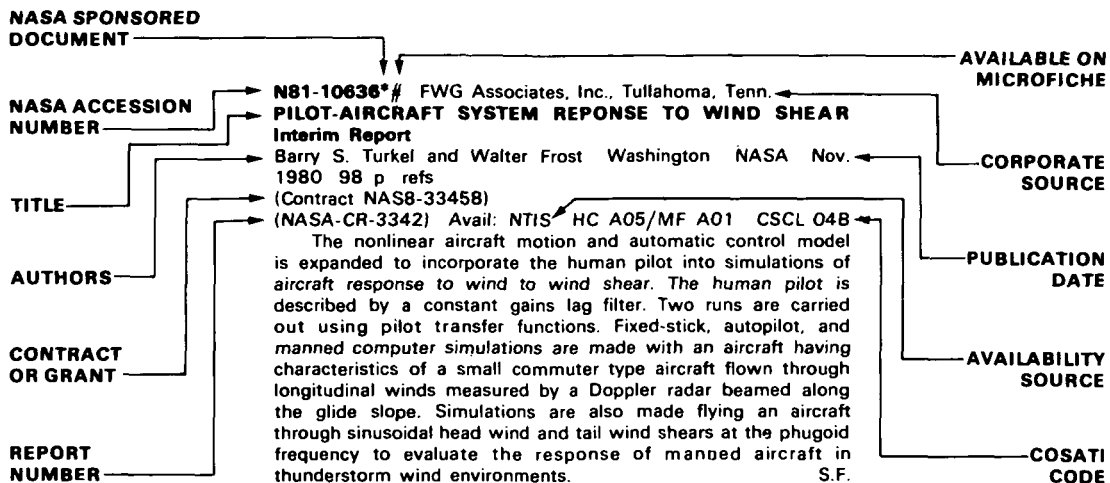
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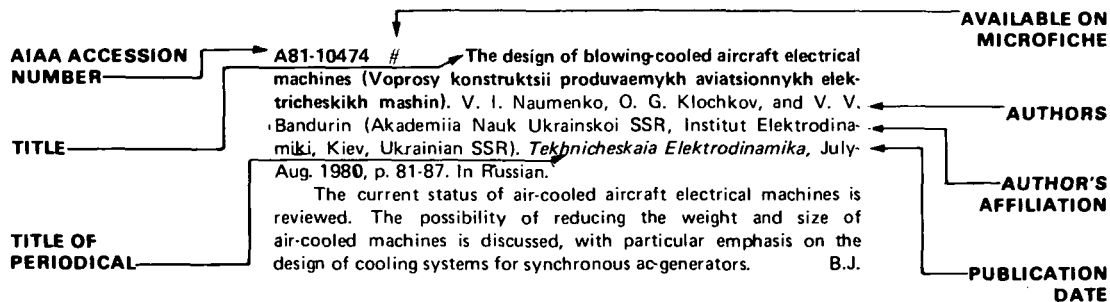
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## TYPICAL CITATION AND ABSTRACT FROM IAA



# AERONAUTICAL ENGINEERING

*A Continuing Bibliography (Suppl. 137)*

JULY 1981

## IAA ENTRIES

**A81-27326**      New developments in the field of solar-terrestrial relationships (Novoe v solnechno-zemnykh svyaziakh). Edited by A. A. Dmitriev. Moscow, Izdatel'stvo Nauka, 1980. 60 p. In Russian.

The influence of solar activity on processes in the earth's atmosphere is considered with emphasis on resulting meteorological phenomena. Particular attention is given to the relationship between the zonal circulation of the atmosphere and the sector structure of the interplanetary magnetic field, the energy quantization of zonal circulation, and the prediction of meteorological fields by the use of exponential orthogonal functions. Also considered are the aerodynamic equations of a free vortex, the interaction of a vortex filament with a surface, and the unification and standardization of vertical temperature distribution measured by a weather tower.      B.J.

**A81-27364 #**      Investigation of asynchronous motors with unstable power-supply frequency for use on aircraft (Issledovanie aviatsionnykh asinkhronnykh dvigatelei s nestabil'noi chastotoi pitaniia). D. A. Avetisyan, M. A. Ermilov, A. A. Maliutin, and V. K. Koliada. *Akademiia Nauk SSSR, Izvestiia, Energetika i Transport*, Jan.-Feb. 1981, p. 42-51. 10 refs. In Russian.

The paper examines the operation and static and dynamic characteristics of three-phase asynchronous motors for use in aircraft power supply systems. The motor is characterized by a power supply frequency that varies in the range of 400-710 Hz and a stable power-supply voltage. As an example, attention is given to the influence of power-supply frequency variations on the operation of a three-phase asynchronous motor used for driving heat pumps.      B.J.

**A81-27371 #**      Characteristics of thermal energy separation in a gas ejector (Ob osobennostiakh termicheskogo energorazdeleniia v gazovom ezhektore). A. A. Stoliarov. *Akademiia Nauk SSSR, Izvestiia, Energetika i Transport*, Jan.-Feb. 1981, p. 159-162. In Russian.

Experimental results are presented on thermal energy separation in an axisymmetric gas ejector for zero and negative ejection coefficients. Two temperature jumps were observed which elevate the temperature of the cooled air in a stepwise fashion in the case of a monotonic increase of counterpressure behind the diaphragm. It is shown that temperature inversion is accompanied by a rather inert restructuring of vortex motion in the ejector mixing chamber and by an additional temperature decrease of the cooled air. It is also shown that a thermoacoustic effect is superimposed on the thermal vortex energy separation, leading to the appearance of resonance maxima of air heating.      B.J.

**A81-27372 #**      Calculation of circular flow inhomogeneities downstream of the turbine wheel (K raschetu okruzhnoi neravnomernosti parametrov potoka za rabochim kolesom turbinnoi stupeni). K. L. Lapshin, V. N. Sadovnichii (Leningradskii Politekhnikeskii

Institut, Leningrad, USSR), and Iu. V. Nakhman. *Energetika*, vol. 24, Jan. 1981, p. 49-52. 5 refs. In Russian.

An approximate method is proposed for calculating the circular flow inhomogeneities downstream of the turbine wheel from the circular inhomogeneities of the flow between the guide nozzles and the wheel. A comparison of the calculated results with experimental data indicates that the proposed method provides a rough estimate of the step inhomogeneity of the flow parameters and angles in the section 2-2 downstream of the wheel.      V.L.

**A81-27373 #**      Aerodynamic study of flat turbine cascades with additional blades in blade passages (Aerodinamicheskoe issledovanie ploskikh turbinnykh reshetok s dopolnitel'nymi lopatkami v mezhlopatochnykh kanalakh). B. P. Bashurov (Leningradskii Korablistroitel'nyi Institut, Leningrad, USSR). *Energetika*, vol. 24, Jan. 1981, p. 104-106. 6 refs. In Russian.

**A81-27374 #**      Gas dynamic characteristics of the nozzle diaphragms of partial supersonic turbines (Gazodinamicheskie kharakteristiki soplovykh apparatov partial'nykh sverkhzvukovykh turbin). K. G. Rodin and V. V. Nosov (Leningradskii Politekhnikeskii Institut, Leningrad, USSR). *Energetika*, vol. 24, Jan. 1981, p. 107-110. In Russian.

The basic gas dynamic characteristics have been obtained for small-size partial nozzle diaphragms with nozzles of rectangular cross section for supercritical pressure differentials in the Reynolds number range 100,000-600,000. The proposed expressions for the nozzle exit angle with allowance for nozzle losses closely approximate experimental data over a wide range of exit area to throat area ratios.      V.L.

**A81-27531 #**      Aeroelastic stability of aircraft (Aerouprugaia ustoiichivost' letatel'nykh apparatov). A. I. Smirnov. Moscow, Izdatel'stvo Mashinostroenie, 1980. 232 p. 119 refs. In Russian.

The book examines the dynamic problems of the theory of aeroelasticity including the classical flutter of long and short wings, empennage and aircraft bodies. Significant problems require computation of aerodynamic loads which demand a proper choice of controls simple in design and adequate with respect to the interaction of the airflow with the load-carrying components of aircraft. The basic aerodynamic expressions based on the Lagrangian integrals are analyzed along with the descriptions of panel and separation flutter effects.      A.T.

**A81-27534 #**      Flight-vehicle antennas /2nd revised and enlarged edition/ (Antenny letatel'nykh apparatov /2nd revised and enlarged edition/). B. A. Prigoda and V. S. Kokun'ko. Moscow, Voenizdat, 1979. 160 p. 20 refs. In Russian.

The work examines the electrical and design properties of various types of radio antennas for use on aircraft, helicopters, rockets, and spacecraft. Particular attention is given to the design and operation of antennas for the short-wave, meter-wave, centimeter-wave, and decimeter-wave ranges, and to the influence of radomes on flight-vehicle antennas.      B.J.

**A81-27548 #** An observational experiment using a monostatic sodar at the airport of Fiumicino (Campagna di misure con sonda acustica monostatica presso l'aeroporto di Fiumicino). S. Palmieri, A. Pulcini (Aeronautica Militare, Servizio Meteorologico, Rome, Italy), N. Di Tommaso (Roma, Università, Rome, Italy), C. Camerucci, B. Bellomo (Ente Nazionale per l'Energia Elettrica, Direzione delle Costruzioni, Rome, Italy), and A. Franciotti (Ente Nazionale per l'Energia Elettrica, Laboratorio Centrale DCO, Piacenza, Italy). *Rivista di Meteorologia Aeronautica*, vol. 40, Oct.-Dec. 1980, p. 267-277. 9 refs. In Italian.

A boundary layer experiment is described in which the observational system consists of a monostatic sodar, computer-processed radiosonde data, and the landing conditions reports of pilots. A simple classification scheme for the echoes received is proposed, with the frequencies of each class of echoes interpreted and thick solid trace cases analyzed in terms of the factors on which they depend. Cases associated with turbulence reported by pilots during landing are considered, together with two cases of visibility reduced by fog. Future refinement of the experimental method described, through the incorporation of Doppler techniques, is recommended. O.C.

**A81-27610** Practical experiences with flow-induced vibrations; Proceedings of the Symposium, Universität Karlsruhe, Karlsruhe, West Germany, September 3-6, 1979. Symposium sponsored by the International Association for Hydraulic Research, IUTAM, U.S. Navy, et al. Edited by E. Naudascher (Karlsruhe, Universität, Karlsruhe, West Germany) and D. Rockwell (Lehigh University, Bethlehem, Pa.). Berlin, Springer-Verlag, 1980. 870 p. \$82.75.

Among the topics discussed are: reactor and heat-exchanger components, hydraulic machinery and equipment, and hydraulic structures. Consideration is also given to marine problems, as encountered in ship structures, ocean structures, and bridge decks, beams and cables, and to wind-induced problems of high-rise buildings and structures. Coverage of a workshop on the prediction and modelling of flow-induced vibrations is given and a concluding section is devoted to critical unresolved topics in all of the fields mentioned. O.C.

**A81-27611** Flutter of plates and shells in practice. E. H. Dowell (Princeton University, Princeton, N.J.). In: Practical experiences with flow-induced vibrations; Proceedings of the Symposium, Karlsruhe, West Germany, September 3-6, 1979. Berlin, Springer-Verlag, 1980, p. 160-174. 21 refs.

Five case histories are presented to illustrate the advances of fundamental understanding in recent years on the problem of flutter of plates and shells. The cases covered are shell flutter of the main shaft of a jet aircraft engine, heat shield flutter in the Space Shuttle Solid Rocket Booster, wind tunnel wall flutter, re-entry missile exit cone flutter, and the flutter of a toroidal membrane at low flow velocities. In each case, flutter was not anticipated and no prior analysis of such phenomena was performed, suggesting that it is important for the available knowledge to be used for design evaluations on a timely basis. O.C.

**A81-27612** Aerodynamic blade excitation in turbo-compressors. R. J. Jenny and U. Bolleter (Gebr. Sulzer AG, Winterthur, Switzerland). In: Practical experiences with flow-induced vibrations; Proceedings of the Symposium, Karlsruhe, West Germany, September 3-6, 1979. Berlin, Springer-Verlag, 1980, p. 256-261, 263, 264; Discussion, p. 262. 5 refs.

The use of classical dynamic strain gauge measurements on stationary and rotating blades, to extract general excitation data and identify different vibration mechanisms, is demonstrated. After dynamic calibration of the test blade by experimental modal analysis making use of a viscoelastic damping model and a generalized force, the resonant frequencies and generalized force are experimentally determined by impact excitation. Results are presented for lower 'engine order' excitations due to distorted oncoming flow, and for

blade excitations due to rotating stall that are found to be a strong source of blade vibration. Stimuli for periodic and stochastic excitation are extracted for both cases, and the averaged data values are complemented by the time history of the stress signals. O.C.

**A81-27878** Aircraft stability at high incidence. A. W. Babister (Glasgow, University, Glasgow, Scotland). *Aeronautical Journal*, vol. 84, Feb. 1980, p. 73-75.

The Kalviste method of analysis of aerodynamic coupling between longitudinal and lateral motion at high incidence, in which aircraft rotary motion alone is considered, is modified. The new method includes certain non-linear aerodynamic effects, and is especially useful in showing some unstable modes that become apparent only on introducing the non-linear terms. O.C.

**A81-27880** Design requirements of agricultural aircraft. R. C. Amsden. *Aeronautical Journal*, vol. 84, June 1980, p. 144-146. 5 refs.

A wide-ranging series of recommendations is made for the design of a third generation agricultural aircraft. The configuration envisioned incorporates such features as tandem wings with wingtip sails, ducted fan propulsion, a square-section fuselage that could accommodate such varied payloads as a freight box, ambulance car or fertilizer hopper, and a high-pilot visibility cockpit bubble. The aircraft would not only be able to operate in STOL conditions from improvised airfields, but would have wake aerodynamic characteristics helpful in the distribution of insecticides, seed and fertilizers from the spraygear. O.C.

**A81-27881** Back to basics - The philosophy adopted for the flight testing of the Panavia Tornado avionics system in hack aircraft. P. H. Morgan. *Aeronautical Journal*, vol. 84, June 1980, p. 147-152.

The approach and specific techniques used in the flight testing and subsequent analysis of the Panavia Tornado aircraft's all-weather NAV/ATTACK avionics system are described. The navigation, terrain-following and weapon aiming functions of the avionics were tested during the 'Stage Three Flight Trials' aboard modified HS Buccaneer Mk 2 aircraft, and their specially designed airborne data acquisition system output was then analyzed at a specially procured Ground Station by a minicomputer. It is concluded that the novel test program successfully characterized avionics system performance without need for exotic or costly new facilities. O.C.

**A81-27882** Developments in aircraft power flying control hydraulics. N. J. Honey. *Aeronautical Journal*, vol. 84, June 1980, p. 153-163.

Aspects of aircraft hydraulic actuators power control design are studied, using as examples the units developed for the BAC One-Eleven, VC10 and Concorde aircraft. Among the major topics discussed are hydraulic supply systems, redundancy and fail-safe considerations, multistage methods of control-signal processing and implementation, the mechanical and electrical origination of control signals, and the future trends in hydraulic control system design, such as fly-by-wire and self-monitoring servo systems. It is concluded that electrically signalled hydraulic actuators will play an increasingly important role in future aircraft flight control systems. A series of explicit diagrams are included. O.C.

**A81-27884** Studies on Thwaites' method for wind tunnel contraction. E. G. Tulapurkara (Indian Institute of Technology, Madras, India). *Aeronautical Journal*, vol. 84, June 1980, p. 167-169. 8 refs.

A general computer program to be used in obtaining axisymmetric wind tunnel contraction shapes according to Thwaites' (1946) method, using any number of terms in the solution, is described. Although the difference between axial and wall velocity at the tunnel exit increases with the number of terms, a uniform velocity distribution is obtained within a distance of 0.2 D1 downstream of the contraction exit. Low adverse pressure gradients at the ends of



contraction and small boundary layer thickness at the exit are obtained for a contraction ratio of between 7 and 16 by values of  $N = 10$  and  $L/D1 = 1$ . O.C.

**A81-27885** Applications of carbon fibre composites to military aircraft structures. T. Sharples (British Aerospace, Aircraft Group, Preston, Lancs., England). (*Royal Aeronautical Society, Symposium on Large Scale Composite Structures, London, England, Apr. 22, 1980.*) *Aeronautical Journal*, vol. 84, July 1980, p. 177-182.

The weight-reduction, performance and economic advantages of carbon fiber composite (CFC) primary structures in military aircraft design are discussed. Among the design considerations covered are static strength, fatigue resistance, composite lay-up effects, notch sensitivity, environmental degradation, and composite variability and resulting material strengths. Performance gains from potential applications are then detailed for the fuselage, control surface, wing and duct structures of a twin-engine, canard configuration fighter aircraft. It is concluded that CFC structures are potentially lower in cost than metal equivalents. O.C.

**A81-27886** The manufacture of composite rotor blades. R. J. Wilson (Westland Helicopters, Ltd., Yeovil, Somerset, England). (*Royal Aeronautical Society, Symposium on Large Scale Composite Structures, London, England, Apr. 22, 1980.*) *Aeronautical Journal*, vol. 84, July 1980, p. 183-187.

The aerodynamic, aeroelastic, vibratory load and strength requirements of composite helicopter rotor blades are considered and fabrication and testing methods and results discussed. The testing program is unique in subjecting spar airfoil and trailing edge skin sections, root and attachments, and root-to-airfoil transition areas, to static-load and both, constant and variable-amplitude fatigue tests, prior to full size testing of the blade assembly. The specific blade designs considered are intended for Westland Sea King and Lynx helicopters. O.C.

**A81-27887** The certification of composite airframe structures. P. R. Guyett and A. W. Cardrick (Royal Aircraft Establishment, Airworthiness Div., Farnborough, Hants., England). (*Royal Aeronautical Society, Symposium on Large Scale Composite Structures, London, England, Apr. 22, 1980.*) *Aeronautical Journal*, vol. 84, July 1980, p. 188-203. 12 refs.

The processes of designing, manufacturing, developing and testing airframe structures that incorporate both composite and metal materials are considered from the standpoint of airworthiness, drawing attention to changes called for in the certification practices that have evolved for all-metal designs. Structural testing is held to be as necessary as in the past for assurance of static and fatigue strength. In light of the inherently greater strength variability of composites, their absorption of moisture and response to temperature variations, it is concluded that the use of conventional full-scale tests must be supplemented by the systematic testing of airframe elements and components that may then be related to full-scale results by means of strain measurements and analyses. O.C.

**A81-27888** Engineering aspects of composite structures for civil aircraft. A. W. Kitchenside (British Aerospace Aircraft Group, Weybridge, Surrey, England). (*Royal Aeronautical Society Symposium on Large Scale Composite Structures, London, England, Apr. 22, 1980.*) *Aeronautical Journal*, vol. 84, July 1980, p. 204-209. 8 refs.

The direct operating cost (DOC) benefits obtainable by the application of carbon fiber composites (CFC) to commercial transport aircraft are considered from the standpoint of manufacturing efficiency and quality control. Laminate composition and fabrication, diamond-tool and water-jet cutting, ultrasonic inspection, curing, fatigue and damage tolerance are examined for the epoxy matrices and carbon fibers currently available to aircraft manufacturers. O.C.

**A81-27889 \*** Wing flapping with minimum energy. R. T. Jones (NASA, Ames Research Center, Moffett Field, Calif.). *Aeronautical Journal*, vol. 84, July 1980, p. 214-217.

A technique employed by Prandtl and Munk is adapted for the case of a wing in flapping motion to determine its lift distribution. The problem may be reduced to one of minimizing induced drag for a specified and periodically varying bending moment at the wing root. It is concluded that two wings in close tandem arrangement, moving in opposite phase, would eliminate the induced aerodynamic losses calculated. O.C.

**A81-27892** A modular low-cost raster-scan colour visual system. P. J. Willis (Bath, University, Bath, Somerset, England). (*Royal Aeronautical Society, Symposium on 'Is Flight Simulation of Academic Interest', London, England, Nov. 22, 1979.*) *Aeronautical Journal*, vol. 84, Aug. 1980, p. 230-232. 9 refs. Research supported by the Science Research Council, Royal Aircraft Establishment, and National Research Development Corp.

University of Sussex, England investigations concerning technical problems of visual representation of realistic scenes in real-time are reported. Flight simulation by such means is difficult to achieve because of its required freedom of movement and orientation in three-dimensional space, coupled with rapid scene changes. The display system described is different from conventional frame store displays in being able to represent moving scenes in real time at low data rates, with an inherently high color resolution that is independent of display resolution. The use of zone management processor modules in the digital hardware of the system leads to easy system expansion at relatively low cost. O.C.

**A81-27893** Flight simulation at Cranfield Institute of Technology. R. J. Golding (Cranfield Institute of Technology, Cranfield, Beds., England). (*Royal Aeronautical Society, Symposium on 'Is Flight Simulation of Academic Interest', London, England, Nov. 22, 1979.*) *Aeronautical Journal*, vol. 84, Aug. 1980, p. 236, 237. Research sponsored by the Ministry of Defence (Procurement Executive).

An account is given of flight simulation-related research activities at the Cranfield, England, Institute of Technology. Among the projects of the institution are a fast, 16-bit microcomputer suited to real-time simulation tasks, motion platform performance monitoring techniques, a 'gravity seat' with variable characteristics, a low-cost helicopter visual system, and simulator assessment and evaluation support services. O.C.

**A81-27894** The role of simulation in automatic flight control systems research. R. A. Prasad, S. L. A. Saoullis, and L. Tsitsilonis (Loughborough, University of Technology, Loughborough, Leics., England). (*Royal Aeronautical Society, Symposium on 'Is Flight Simulation of Academic Interest', London, England, Nov. 22, 1979.*) *Aeronautical Journal*, vol. 84, Aug. 1980, p. 238-243. 13 refs. Research supported by the Science Research Council.

To illustrate how computerized simulation is used by the Flight Control Systems Research Group at Loughborough University, England, three applications of the Simulation Language for Analog Modelling (SLAM) are detailed. These are the design of a station-keeping control system for a helicopter with a suspended load, the study of a ride control system for an executive jet transport aircraft, and the study of a structural load alleviation control system for a large cargo aircraft. O.C.

**A81-27897** The M.45SD-02 variable pitch geared fan engine demonstrator test and evaluation experience. G. H. Wright (Rolls-Royce, Ltd., Aero Div., Derby, England) and J. G. Russell (Dowty Rotol, Ltd., Gloucester, England). *Aeronautical Journal*, vol. 84, Sept. 1980, p. 268-277. 6 refs.

Performance requirements, design history and development program to date of the RB 410 engine's M.45S Variable Pressure (VP) fan are discussed. The VP fan has a set of 14 variable-incidence,

thrust-reversing blades fabricated from Duralumin alloy actuated by a gear mechanism designed to withstand extreme centrifugal loading at design rotational speeds. Among the advantages of such a variable-incidence system are: a high takeoff/cruise thrust ratio, highly responsive control, and very low noise levels. A detailed account of the component and system test programs is provided, including bird strike, blade root fatigue, hub overspeed, hydraulic system and noise tests. The practicality of the VP fan has been demonstrated and points to incorporate in future designs have been stressed, including a piston type actuator and a non-self-contained oil tank and pump. O.C.

**A81-27898** An objective method of assessing the realism of a simulation of a simple control system. W. H. Ekin (Robert Gordon's Institute of Technology, Aberdeen, Scotland) and D. McCloy (Ulster Polytechnic, Newtownabbey, Northern Ireland). *Aeronautical Journal*, vol. 84, Sept. 1980, p. 278-281. Research supported by the Ministry of Defence.

An experimental apparatus for manual control was devised and tested by means of which discrepancies between the behavior of simulation equipment and the system simulated can be determined and a compensating calibration effected. The device consists of a single degree of freedom inverted pendulum that is balanced by manually moving a carriage to which the pendulum fulcrum has been attached. The power spectral density functions of the operator's hand displacements and the pendulum's angular displacements were calculated for both the real and the simulated task. O.C.

**A81-27900** Effect of contraction on screen-generated turbulence. E. G. Tulapurkara and V. Ramjee (Indian Institute of Technology, Madras, India). *Aeronautical Journal*, vol. 84, Sept. 1980, p. 290-295. 14 refs.

An experimental study was conducted to determine the relative agreement with test data of the rapid distortion theories proposed for the effect of screens and contraction in wind tunnels. It was found that when the natural rate of decay of turbulence is low ahead of contraction, the increase in longitudinal turbulence kinetic energy can be observed for a contraction ratio as low as four. The transfer of energy from the lateral to the longitudinal kinetic energy component, as a consequence of the tendency to isotropy, is inadequate to account for the large increase in the longitudinal component observed in contractions. It is concluded that a modification of the strain term in turbulence models is needed in order to account for an increase that appears to be proportional to a power of mean velocity at a station/mean velocity ahead of contraction. O.C.

**A81-27901** A pursuit of the aerial carriage /25th Henson and Stringfellow Memorial Lecture/. O. L. L. Fitzwilliams (Westland Helicopters, Ltd., Yeovil, Somerset, England). *Aeronautical Journal*, vol. 84, Oct. 1980, p. 299-315. 14 refs.

An autobiographical and technical account is given of the author's preoccupation with the design and operational characteristics of vehicles that could alternately serve as either automobiles or VTOL, rotary-wing aircraft. The conceptual development process culminates in the formulation of the Independently Targeted Vehicle (ITV), a robotic helicopter/auto with automated collision-avoidance systems. O.C.

**A81-27902** Progress in the use of automatic flight controls in safety critical applications. R. W. Howard (Marconi Avionics, Ltd., Rochester, Kent, England). (*European Pioneers' Day, 5th, Braunschweig, West Germany, May 29, 1980.*) *Aeronautical Journal*, vol. 84, Oct. 1980, p. 316-326.

Automatic landing systems, which were the first safety critical flight control systems to be approved for regular operations, are used as the conceptual basis for the design and assessment of a variety of such systems extensively employing microelectronics. The new digital devices incorporate redundant computing architectures such as triplex-monitoring and dissimilar hardware/software systems.

Although established assessment principles should be applicable to most of the new safety critical systems, it is recommended that more rigorous aerodynamic, structural and atmospheric turbulence models be developed for a more sophisticated evaluation of the emerging ride control and load alleviation active control technologies. O.C.

**A81-27903** The development of multiple redundant flight control systems for high integrity applications. J. M. Corney (Marconi Avionics, Ltd., Flight Controls Div., Rochester, Kent, England). *Aeronautical Journal*, vol. 84, Oct. 1980, p. 327-338.

The Command/Stability Augmentation System (CSAS) of the Panavia Tornado, a triplex analog maneuver demand system providing fly-by-wire operation to control surfaces, and the Boeing YC-14 Electrical Flight Control System (EFCS), a STOL-operation three-axis autostabilization system also providing automatic compensation for the effects of engine failure, are described. Among the characteristics and functions of the systems covered are command/stability, autopilot/flight direction, sensor consolidation and computer synchronization, redundancy requirements and the mechanical and electronics aspects of control surface actuation. O.C.

**A81-27905** Combat aircraft development - Looking backward to look forward 1935-1990. R. D. Boot (British Aerospace, Warton Div., Preston, Lancs., England). *Aeronautical Journal*, vol. 84, Nov. 1980, p. 349-357.

An historical analysis is given of the performance characteristics and economics of fighter aircraft designs over a period of 45 years, including 25 U.K. and 20 U.S. types, with attention to the feasibility study/design phases of aircraft development. Consideration is then given to the range of technological possibilities that a new-generation aircraft may incorporate, including aerodynamics, structures, electronics, cockpit instrumentation, propulsion and even computerized, interactive-design methodologies. It is concluded that the accelerating cost increases for manned, high-technology aircraft make consideration of remote-controlled or robotic unmanned aircraft very attractive, but that the near term calls for the application of design tools to cost reduction in manned replacements for existing forces. O.C.

**A81-27907** Airbus Industrie - Past, present and future /26th Mitchell Memorial Lecture/. D. G. Brown (Airbus Industrie, Blagnac, Haute-Garonne, France). *Aeronautical Journal*, vol. 84, Dec. 1980, p. 395-407.

An historical account is given of the Airbus Industrie consortium formation, formulation of A300 and A310 airliner designs, industrial production organization, and product development to date. On the strength of prospective gains in fuel efficiency, through the application of advanced materials and construction techniques to aircraft structures, aerodynamic design advances and engine refinements, the development of several additional aircraft designs is projected. O.C.

**A81-27910** # Light transmission measurements in solid fuel ramjet combustors. M. E. Hewett and D. W. Netzer (U.S. Naval Postgraduate School, Monterey, Calif.). *Journal of Spacecraft and Rockets*, vol. 18, Mar.-Apr. 1981, p. 127-132. 15 refs. Navy-sponsored research.

An experimental investigation of the combustion behavior in solid fuel ramjets was conducted using polymethylmethacrylate fuel grains. Multiple wavelength light transmission measurements were made at the fuel grain exit and nozzle entrance to study the effects of bypass ratio on the combustion efficiency and the percentage and size of unburned carbon. Utility and limitations of the optical method are presented. Combustion efficiency did not correlate with the percentage of unburned carbon. Unburned hydrocarbons were the apparent cause of combustion inefficiency. Fuel regression rate and combustion efficiency were also found to be sensitive to small variations in fuel manufacturing methods. (Author)

**A81-27911 #** Correlation of artificially induced boundary-layer transition data at hypersonic speeds. A. H. Boudreau (ARO, Inc., Arnold Engineering Development Center, Arnold Air Force Station, Tenn.). *Journal of Spacecraft and Rockets*, vol. 18, Mar.-Apr. 1981, p. 152-156. 7 refs. Research sponsored by the U.S. Department of Transportation and U.S. Air Force.

Previous investigations of distributed-roughness boundary-layer trips indicated that they are superior to spherical-type trips in that equally effective distributed-roughness trips are one-fifth as high and produce substantially smaller flowfield disturbances. The present work has expanded the data base, permitting correlation of distributed-roughness tripping data. The correlation thus developed includes a wide range of Reynolds numbers, cone angles, and trip heights. Plots are provided that permit the selection of distributed-roughness trips without the need of boundary-layer solutions.

(Author)

**A81-27943** Some experience with ferrography in monitoring the condition of aircraft engines. W. Hoffmann (Institut für Betriebsstofftechnik, Munich, West Germany). *Wear*, vol. 65, Jan. 1, 1981, p. 307-313.

The use of ferrographic oil analysis is examined for detecting the incidence and build-up of debris particles too large to be detected by spectrographic oil analysis and too small to be detected conveniently by magnetic plugs. With the direct reading ferrograph, 1 ml of lubricant is siphoned through a precipitation tube and the optical densities of the deposits are observed at selected distances. A single figure severity-of-wear index is obtained from which significant monitoring data can be derived. In the analytical ferrograph, 3 ml of the lubricant sample diluted with a solvent for promoting precipitation of the wear particles is pumped over a transparent substrate to which the wear particles adhere. Using a ferrogram reader attached to a bichromatic microscope, the optical densities of the deposits can be observed to determine the severity-of-wear index from the percentage areas covered by the particles. The particles fixed on the ferrogram can be examined in a bichromatic or scanning electron microscope. L.S.

**A81-28078 #** Calculation of shells in aircraft turbine engines (Problemy obliczania powłok w turbinowych silnikach lotniczych). Z. Dzygadlo (Wojskowa Akademia Techniczna, Warsaw, Poland). *Mechanika Teoretyczna i Stosowana*, vol. 18, no. 3, 1980, p. 391-399. 17 refs. In Polish.

A method is presented for the calculation of compressor and turbine rotors of aircraft engines that is based on the use of shell, plate, and disk finite elements. It is assumed that the rotors under consideration rotate at constant angular velocity; their elements are subject to mass forces induced by rotation, tensile forces from the blade rims, and surface forces due to the difference of pressures at different stages of compressor or turbine. Methods are developed for determining displacements, stresses and strains, as well as for calculating free and forced vibrations. B.J.

**A81-28108** Fatigue strength of certain materials used in airframe construction. I. P. Bareishis and S. A. Darguzhis (Kaunas Politechnisches Institut, Kaunas, Lithuanian SSR). (*Mekhanika Kompozitnykh Materialov*, May-June 1980, p. 451-455.) *Mechanics of Composite Materials*, vol. 16, no. 3, Nov. 1980, p. 320-324. 12 refs. Translation.

Specimens of hot-curing carbon plastic, glass/epoxy plastic reinforced with glass rovings, and epoxy plastics filled with 20% ZnO or 3-4 micron diameter glass spheres have been tested under cyclic loading. It is found that loss of rigidity in all composites tested is largely due to damage accumulation; a change in dynamic rigidity per loading cycle can be used as a measure of the fatigue fracture development. It is also found that the fatigue strength of the carbon plastic is 2.5 times higher than that of the glass/epoxy composite. V.L.

**A81-28128** Integral methods for solving thermal conductivity problems and their application to evaluating heat exchange in certain gas-turbine elements. Iu. S. Vytychikov and V. M. Khorol'skii (Kuibyshevskii Politekhnikheskii Institut, Kuibyshev, USSR). (*Problemy Prochnosti*, July 1980, p. 85-88.) *Strength of Materials*, vol. 12, no. 7, Mar. 1981, p. 897-901. Translation.

The paper examines an approximate integral computation method for thermal fields in gas turbine blades and gas turbine engine combustion chambers. The calculated thermal fields in gas turbine blades are to determine thermal stresses. Analytical computations were compared with electrical modelling data. A.T.

**A81-28134** Increased fatigue resistance for blades of stationary gas-turbine engines by ultrasonic hardening with spherical particles. Ia. I. Bliashko, V. A. Volosatov, D. M. Bavel'skii, G. I. Bogoradovskii, V. Iu. Veroman, and A. V. Ivanov (Leningradskii Metallicheskiy Zavod, Leningrad, USSR). (*Problemy Prochnosti*, July 1980, p. 112-115.) *Strength of Materials*, vol. 12, no. 7, Mar. 1981, p. 927-929. 5 refs. Translation.

**A81-28293** Radio Technical Commission for Aeronautics, Technical Symposium and Annual Assembly Meeting, Washington, D.C., November 20, 21, 1980, Proceedings. Edited by J. Alcorn (Radio Technical Commission for Aeronautics, Washington, D.C.). Washington, D.C., Radio Technical Commission for Aeronautics, 1980. 190 p. \$16.

The topics discussed are the impact of active controls on aircraft design and operations, cockpit displays and systems to aid the pilot, and emerging electronic systems and their impact on air traffic control. Particular consideration is given to the impact of active controls on helicopter design and operations, the application of CRT displays to new generation aircraft, and the Discrete Address Beacon System. P.T.H.

**A81-28294 #** Impact of active controls on aircraft design and operations - A helicopter industry perspective. E. S. Carter (United Technologies Corp., Sikorsky Aircraft Div., Stratford, Conn.). In: Radio Technical Commission for Aeronautics, Technical Symposium and Annual Assembly Meeting, Washington, D.C., November 20, 21, 1980, Proceedings. Washington, D.C., Radio Technical Commission for Aeronautics, 1980, p. 23-40. 15 refs.

The paper describes the characteristics of rotorcraft that offer unique opportunities for application of active control technology, briefly reviews the history of electronic control utilization by rotorcraft, and attempts to forecast the future trends of utilization active control technology in the helicopter industry. The application of the following active control and fly-by-wire elements to helicopters is considered: stability augmentation and attitude command, relaxed longitudinal stability, flight path command, ride smoothing, FBW control system and side arm control, maneuver load relief, and flight control/fuel control integration. P.T.H.

**A81-28295 #** The impact of active controls on general aviation airplanes of the late 1980s. J. Roskam (Kansas, University, Lawrence, Kan.). In: Radio Technical Commission for Aeronautics, Technical Symposium and Annual Assembly Meeting, Washington, D.C., November 20, 21, 1980, Proceedings. Washington, D.C., Radio Technical Commission for Aeronautics, 1980, p. 41-47.

Active flight controls in general aviation could have the following applications: full-time stability augmentation, gust and/or load alleviation, and flutter suppression. It is suggested that active flight controls will not significantly impact general aviation aircraft design of the 1980's unless LCC effectiveness is demonstrated, certification procedures are perceived in a better light, more qualified cross-disciplined engineers are available, and new designs adapt either SSSA or electrohydraulic flight controls. P.T.H.



**A81-28296 # Head up displays.** C. Maureau (Thomson-CSF, Paris, France). In: Radio Technical Commission for Aeronautics, Technical Symposium and Annual Assembly Meeting, Washington, D.C., November 20, 21, 1980, Proceedings. Washington, D.C., Radio Technical Commission for Aeronautics, 1980, p. 61-69.

Head-up displays are discussed in the light of two main features: the fact that they are open displays which present information to the pilot without depriving him of his simultaneous external view, and the fact that these displays give to the pilot information with a directional value. Several remarks are made about the future utilization of head-up displays. It is suggested that HUD's will be designed not by equipment manufacturers working on their own, but in discussion and collaboration with aircraft manufacturers responsible for the overall cockpit design. In addition, modern HUDs will be installed aboard training aircraft to give an early start to the education of pilots of future operational aircraft, civilian as well as military.

P.T.H.

**A81-28297 # Application of CRT displays to new generation aircraft.** B. C. Hawkins (Rockwell International Corp., Collins Air Transport Div., Cedar Rapids, Iowa). In: Radio Technical Commission for Aeronautics, Technical Symposium and Annual Assembly Meeting, Washington, D.C., November 20, 21, 1980, Proceedings. Washington, D.C., Radio Technical Commission for Aeronautics, 1980, p. 71-86.

Since the application of the multicolor Electronic Flight Instrument System (EFIS), the use of color CRT displays has rapidly increased in new generation aircraft. Some of the more prominent systems are the 757 Engine Indication and Crew Alerting System (EICAS), the A310 Electronic Warning and System Display (EWSD), and the 767 Caution Annunciator Indicator (CAI). The present paper discusses CRT display technology and describes some of the systems. It is concluded that, in general, the CRT display applications have resulted in 'clean cockpit', multimode advanced symbology displays and increased crew awareness of the aircraft state and situation.

P.T.H.

**A81-28298 # New directions in cockpit alerting.** P. A. Roitsch (Air Line Pilots Association, Washington, D.C.). In: Radio Technical Commission for Aeronautics, Technical Symposium and Annual Assembly Meeting, Washington, D.C., November 20, 21, 1980, Proceedings. Washington, D.C., Radio Technical Commission for Aeronautics, 1980, p. 95-106.

Results of a study on cockpit alerting are reported. It is suggested that a good warning system must have the following elements: (1) it must never actuate when operations are normal; (2) it must always actuate when a problem exists; (3) it must state clearly and precisely to the crew the exact nature of the problem; and (4) it must determine and annunciate the level of urgency by sensing flight conditions. It was concluded that the system should have a visual display, a voice capability, and an attention-getting tone. Specific recommendations are presented on the delivery system and its philosophy, levels of urgency, and inhibit logic.

P.T.H.

**A81-28299 # Boeing 757 and 767 Flight Management System.** R. E. Spradlin (Boeing Commercial Airplane Co., Seattle, Wash.). In: Radio Technical Commission for Aeronautics, Technical Symposium and Annual Assembly Meeting, Washington, D.C., November 20, 21, 1980, Proceedings. Washington, D.C., Radio Technical Commission for Aeronautics, 1980, p. 107-118.

The Boeing 757 and 767 Flight Management System (FMS) provides the first integrated design application of advanced digital computing and display technologies to modern commercial jet transport aircraft. FMS is characterized by the federated system architecture and the system interface with the flight crew. The basic features of the system are discussed in this paper, including the flight management computer, the autopilot flight director system, the thrust management system, the inertial reference system, the

electronic flight instrument system, the caution and warning system, and the engine indication and crew alerting system.

P.T.H.

**A81-28300 \* # Electronic search and rescue aids.** B. J. Trudell (NASA, Goddard Space Flight Center, Greenbelt, Md.). In: Radio Technical Commission for Aeronautics, Technical Symposium and Annual Assembly Meeting, Washington, D.C., November 20, 21, 1980, Proceedings. Washington, D.C., Radio Technical Commission for Aeronautics, 1980, p. 137-145. 8 refs.

There are two elements to the basic electronic search and rescue problem: a means for immediately alerting potential rescuers and an effective method to guide the rescue forces to the scene of the emergency. An Emergency Locator Transmitter (ELT) used by aircraft or an Emergency Position Indicating Radio Beacon (EPIRB) used by maritime vessels has the capability of providing for both an immediate alert and a homing signal to assist rescue forces in locating the site of the distress. This paper describes the development of ELT/EPIRB systems. Emphasis is placed on the SARSAT project, the COSPAS/SARSAT project, and an experimental 406 MHz ELT/EPIRB system.

P.T.H.

**A81-28301 # RTCA looks at DABS avionics.** A. B. Winick. In: Radio Technical Commission for Aeronautics, Technical Symposium and Annual Assembly Meeting, Washington, D.C., November 20, 21, 1980, Proceedings. Washington, D.C., Radio Technical Commission for Aeronautics, 1980, p. 147-161.

A status report is presented on the work of the RTCA group charged with developing minimum operational performance standards for the Discrete Address Beacon System (DABS). Three critical issues of a system nature are examined: the need for antenna diversity, data interfaces and the need for 'real-time' data transfer capability, and transponder capability levels. Attention is also given to signal transmission in space, and signal content and protocols.

P.T.H.

**A81-28302 # Advanced ATC computer system.** N. A. Blake (FAA, Washington, D.C.). In: Radio Technical Commission for Aeronautics, Technical Symposium and Annual Assembly Meeting, Washington, D.C., November 20, 21, 1980, Proceedings. Washington, D.C., Radio Technical Commission for Aeronautics, 1980, p. 163-168.

The FAA's ATC Computer Replacement Program is discussed. It is noted that the FAA is taking a number of steps to extend the life of the current 9020 computer systems until the late 1980's. The current computer systems, however, do not have the capacity to accommodate traffic growth much beyond the late 1980's and fall far short of meeting the capacity requirements of the future automated functions. The combined pressures of traffic growth, aging computer systems, and the need to implement higher-levels of automation in the late 1980's have led the FAA to embark on an expedited program which would bring the systems and the new automation capabilities on-line in the late 1980's.

P.T.H.

**A81-28461 Building the Gossamer Albatross.** M. Grosser. *Technology Review*, vol. 83, Apr. 1981, p. 52-63.

The design, development and construction of the Gossamer Albatross, the first human-powered aircraft to cross the English Channel, are discussed. Advances over the technology of the first successful human-powered aircraft, the Gossamer Condor, represented by the second-generation Albatross design include the use of carbon-fiber reinforced plastic spars instead of aluminum tubing for the airframe, which required the development of a special tube-winding machine for the fabrication of 12-ft wing sections from the epoxy-impregnated carbon-fiber sheet. Other uses of plastic include the ribs of the wing, wing leading edges and stabilizer, the propeller, control lines, wheels, canard antiyaw cords, drive chain, windshield and structural covering. Changes in configuration from the Condor design also include an upright pilot position, less wing area, a smaller wing sweepback, and Mylar wing covering. Flight tests uncovered various problems with the controls, horsepower demands and

ventilation, and were accompanied by a propeller redesign. The test program ultimately resulted in a test lasting 1 hr 9 min 3 sec which demonstrated the readiness of the craft and pilot for the channel crossing. S.C.S.

**A81-28470** The maintenance of the Airbus from the user's point of view (*L'entretien de l'Airbus vu du côté des utilisateurs*). P. Kleitz (Compagnie Nationale Air France, Paris, France). *L'Aéronautique et l'Astronautique*, no. 85, 1980, p. 5-28. In French.

Airline experience with the operation and maintenance of the A 300 Airbus is related. Statistical data concerning the monthly flight times, take-offs, daily utilization and mean flight time per stage are presented which demonstrate the comparability of the B2 Airbus and the Boeing 727, and the greater utilization of the B4 Airbus following its introduction. The reliability of Airbus operations as compared to the 727 is examined in the areas of lateness due to technical problems, rate of technical incidents, engine reliability with respect to unplanned engine changes and in-flight failures, automatic flight control system reliability, all-weather landing performance, and flaws detected in flight and on the ground in the air conditioning, automatic pilot, communications, electrical generation, automatic loading, fire protection, flight command, hydraulic, navigation, landing, lighting, and oxygen systems. The structural reliability of the aircraft is also considered, and the reliability of the components of the CF6-50 engines is analyzed. Maintenance methods used are indicated, and plans for the acquisition of additional Airbus aircraft are pointed out as evidence of their success. A.L.W.

**A81-28471** General considerations on the importance of reliability studies for helicopters (*Considérations générales sur l'importance pour les hélicoptères des études de fiabilité*). G. Petit (Société Nationale Industrielle Aérospatiale, Division Hélicoptères, Marignane, Bouches-du-Rhône, France). *L'Aéronautique et l'Astronautique*, no. 85, 1980, p. 29, 30. In French.

Various aspects of the problem of the reliability of both civil and military helicopters are discussed. Possible sources of the apparent lag between helicopter and commercial aircraft reliability are considered, including outdated analysis methods and the difficulty of obtaining statistical data for helicopters. The three classical aspects of reliability are indicated, with particular attention given to operational safety, and it is noted that the rates of fatal helicopter accidents are comparable to those in general aviation. The principle causes of helicopter accidents are also pointed out. A.L.W.

**A81-28472** General remarks on helicopter reliability (*Généralités sur la fiabilité des hélicoptères*). F. Liard and R. Garcin (Société Nationale Industrielle Aérospatiale, Marignane, Bouches-du-Rhône, France). *L'Aéronautique et l'Astronautique*, no. 85, 1980, p. 31-37. In French.

Helicopter reliability is discussed in view of the increasing demands on cost effectiveness being expressed by both civil and military users. Following a review of the various types of reliability applied to helicopters, including mission reliability, maintenance reliability and safety reliability, the determination of component lifetimes with respect to structural fatigue is examined. The optimization of materials with respect to minimum failure rate and to minimum costs is considered, and it is shown that whereas in the first case the time between replacements should be set before the time at which wear becomes apparent, in the second the optimum replacement interval depends on the ratio of the cost of a programmed replacement to that of a nonprogrammed replacement, which also determines the maintenance and inspection strategies. A.L.W.

**A81-28473** The reliability of helicopter reduction gears (*Fiabilité des réducteurs d'hélicoptères*). R. François (Société Nationale Industrielle Aérospatiale, Marignane, Bouches-du-Rhône, France). *L'Aéronautique et l'Astronautique*, no. 85, 1980, p. 38-47. In French.

Consideration is given to the predictive and actual reliability of

helicopter reduction gears. The transmission systems of the single-engine Alouette II, the twin-engine SA 330 PUMA and the three-engine SA 321 Super Frelon helicopters are illustrated, with particular attention given to the primary reduction gear located under the main rotor. The sources of damage to the reduction gear are classified as fatigue cracking of the gear teeth or shafts, surface damage, and lubrication and cooling defects. Means for the prediction of reduction gear reliability during the design phase are examined, and it is pointed out that in all cases the actual reliability is superior to that predicted by theoretical calculations. Means for in-flight and ground-based flaw detection are also indicated. Progress made in the improvement of reduction gear reliability by the improvement of design methods and replacement policies is then discussed. A.L.W.

**A81-28474** Helicopter blade reliability (*La fiabilité des pales d'hélicoptères*). J. Hamann and A. Barbillet (Société Nationale Industrielle Aérospatiale, Division Hélicoptères, La Courneuve, Seine-Saint-Denis, France). *L'Aéronautique et l'Astronautique*, no. 85, 1980, p. 49-58. In French.

The reliability of helicopter blades is considered in view of the advances represented by the use of plastic (composite material) blades. The designs of metallic and plastic blades are compared, and the complex aerodynamic forces giving rise to rotor blade fatigue are pointed out. Possible causes of blade damage are indicated, and the means of repairing damaged metal and plastic blades are discussed. The assurance of the safety reliability of rotor blades at the levels of design, fabrication and quality control are considered, and methods for the determination of the actual in-service reliability of metal and plastic blades are presented. Results of evaluations demonstrating the superior lifetimes and environmental and operations stress resistance of two types of plastic blades are indicated, and it is pointed out that after 10 years of operating experience, no aging has yet been observed in the plastic helicopter rotor blades. A.L.W.

**A81-28475** Jet engine maintenance and reliability programs - Objectives and management (*Les programmes de maintenance et de fiabilité réacteurs - Objectifs et management*). J. A. Aguer (Compagnie Nationale Air France, Paris, France). *L'Aéronautique et l'Astronautique*, no. 85, 1980, p. 59-69. In French.

Consideration is given to policies of jet engine maintenance and the management of the programs set up for this purpose. The objectives, philosophies and characteristics of maintenance undertaken on the level of propulsion reliability programs specific to each user consisting of official maintenance regulations and maintenance programs specific to each aircraft and user which consist of practical guidelines for the execution and planning of maintenance procedures are reviewed. The evolution of maintenance policies in Europe and the U.S. over the past 20 years from those of fixed general replacement schedules to phase II maintenance according to state and research on component utilization limits is traced. Considerations of the increasing complexity of jet engines, the monitoring of engine performance and cost effectiveness in the management of engine maintenance programs are presented, and objectives of work in the improvement of engine reliability is discussed, with attention given to the service life of high-pressure turbine blades, reduced thrust operation, and the deterioration of jet engine performance. A.L.W.

**A81-28523 #** A method for measuring the velocity field in a stalled flow (*O metodike izmereniia polia skorosti v otryvnom techenii*). B. S. Agrovskii, E. P. Anisimova, A. G. Zatsepin, M. M. Maseev, and A. A. Speranskaia. *Moskovskii Universitet, Vestnik, Seriia III - Fizika, Astronomiia*, vol. 22, Jan.-Feb. 1981, p. 83-87. 6 refs. In Russian.

A method is proposed for measuring the velocity field in a stalled flow which employs a mechanotron as a velocity transducer. In the absence of flow separations, the horizontal component profile of the mean velocity measured by a hot-wire anemometer, used as a reference instrument, is compared with that measured by a mechano-

tron anemometer. It is shown that the hot-wire anemometer is unsuitable for measuring velocity fields in a stalled flow. V.L.

**A81-28574 #** Effect of the discharge circuit parameters on the weight, dimensions, and energy characteristics of the power supply source (Vliianie parametrov razriadnogo kontura na massogabaritnye i energeticheskie kharakteristiki istochnika pitaniia). R. M. Muzafarov, D. B. Kofman, and Iu. I. Kovan (Moskovskii Aviatzionnyi Institut, Moscow, USSR). *Tekhnicheskaya Elektrodinamika*, Jan.-Feb. 1981, p. 103-106. In Russian.

Analytic expressions have been obtained which relate charging unit characteristics to the discharge circuit parameters. Calculation of power supply design parameters from the discharge circuit characteristics (capacity, load impedance, and discharge time) is illustrated by an example. V.L.

**A81-28578 #** Numerical solution of the direct one-dimensional problem of a critical flow in nozzles (Chislennoe reshenie priamoj odnomernoi zadachi kriticheskogo techeniia v soplakh). V. V. Nevinskii, V. I. Rozenblum, and M. I. Savel'ev. *Inzhenerno-Fizicheskii Zhurnal*, vol. 40, Mar. 1981, p. 427-431. 9 refs. In Russian.

The paper examines various numerical schemes for the integration of common differential equations which describe the flow of heterogeneous fluids in nozzles. A simple model problem - subcritical and critical flow of an ideal gas through Laval nozzle - is used as an example. It is shown that continuous transition over a singular point can be realized only by the Euler method. It is emphasized that the solution algorithm should be based on a fully conservative scheme. V.L.

**A81-28599** Supersonic V/STOL prospects brighten. M. Wilson. *Interavia*, vol. 36, Mar. 1981, p. 219, 220.

Factors influencing the future development of supersonic V/STOL aircraft are discussed. The paper reports that full-scale development and construction of the AV/8B V/STOL fighter bomber has been approved by the U.S. Government. The development of the AV-8B with Mach 1.5 and ready in 1985-86, and with Mach 2 ready in 1995-2005, are two possible ways forward for the supersonic V/STOL program. By choosing the AV-8B to replace its Harriers and Jaguars, the RAF may influence the prospect of an eventual supersonic follow-on. Attention is given to the propulsion system (which probably will be based around the Pegasus), which is the key factor in both long and short term supersonic V/STOL combat projects. The Pegasus 11 develops 9750 kg thrust, a development to 11,110 kg is projected as the Pegasus 11-35; both are proposed as foundations for PCB developments, e.g., the Pegasus 11-35, proposed for the AV-8SX, would generate 15,900-18,000 kg thrust to match the probable take-off weight of 15,900-16,800 kg. K.S.

**A81-28614 #** The possibilities of improving the efficiency of gas turbines (Die Möglichkeiten zur Verbesserung des Wirkungsgrades der Gasturbinen). F. Toth. *Acta Technica*, vol. 89, no. 3-4, 1979, p. 347-352. In German.

Advantages of multistage chamber turbines over traditional blade turbines are discussed. Possible improvements in efficiency fall into three areas: gains in the maximal amount of mechanical energy from the thermal energy of the gas, transformation of mechanical energy of gas into useful work, and utilization of the energy of the consumed gas as useful work. The advantages of the chamber turbines are that the gas does double work in all expansions except the last and that the pressure energy of the gas can be utilized during combustion as well as at the outflow from the chamber. Multistage chamber turbines utilize, at optimal speed of rotation, only 40% of the kinetic energy of the gas; the outer 60% results from the pressure energy of the gas. The major advantage of chamber over blade turbines is that they incur fewer aerodynamic losses in their utilization of pressure energy. D.K.

**A81-28676** On a generalization of Kaden's problem. D. I. Pullin (Melbourne, University, Parkville, Victoria, Australia) and W. R. C. Phillips (University of Singapore, Singapore). *Journal of Fluid Mechanics*, vol. 104, Mar. 1981, p. 45-53. 17 refs. National Energy Research, Development and Demonstration Council of Australia Contract No. 9240.

Kaden's problem of the roll-up of an initially planar semiinfinite vortex sheet with a parabolic distribution of circulation is extended to include vortex sheets exhibiting a general power law circulation distribution, resulting in the presence of a power law, and in one case a logarithmic-like, velocity-field singularity. Both semiinfinite and infinite initially plane sheets with this property are considered and the form of their roll-up in the similarity plane, into single and double-branched spirals respectively, is obtained numerically. Estimates of the Betz constant obtained from the solutions are found to be significantly different from values predicted by the Betz approximation. (Author)

**A81-28698** Aircraft and air pollution. D. F. Naugle (USAF, Biomedical Sciences Corps, Chapel Hill, N.C.) and D. L. Fox (North Carolina, University, Chapel Hill, N.C.). *Environmental Science and Technology*, vol. 15, Apr. 1981, p. 391-395. 19 refs.

Pros and cons of the need for and the extent of federal regulations for controlling air pollution from aircraft are discussed. It is shown that aircraft emissions are only a small part of total emissions from all sources on a national scale. However on the regional scale, where air pollution effects on health have been identified, aircraft emissions, of which hydrocarbons and NO(X) are the major concern, play an important part. Emission analyses, dispersion modeling, and ambient measurement studies all present evidence of the effect of aviation on ambient air quality while results of previous studies indicate that aircraft are not a direct cause on health and welfare effects. The regulatory picture is further complicated by the military, which is not subject to EPA standards. Recommendations for future air pollution control are given, including an ICAO set of standards. K.S.

**A81-28740** Suboptimal constant output feedback and its application to modern flight control system design. E. Y. Shapiro, D. A. Fredricks, and R. H. Rooney (Lockheed-California Co., Burbank, Calif.). *International Journal of Control*, vol. 33, Mar. 1981, p. 505-517. 12 refs.

An applications-oriented approach to the generation of optimal output feedback gains which is independent of the open loop stability is described for linear, time-invariant systems. The problem of the generation of sub-optimal output feedback is cast in the setting of a constrained parameter optimization problem that employs Hestenes' method of multipliers with some modifications. Detailed algorithm descriptions and computational results for a realistic flight control design problem are provided. O.C.

**A81-28743 #** Device for lubricant flow measurement and conservation (Gerät für Schmierstoffdurchflussmessung und Konservierung). W.-D. Krohs and M. Schenker (Gesellschaft für Internationalen Flugverkehr mbH, Berlin, East Germany). *Technisch-ökonomische Information der zivilen Luftfahrt*, vol. 16, no. 5, 1980, p. 261-263. In German.

**A81-28744 #** The automated transport process management system of INTERFLUG/PRIKAS/ (Das System der automatisierten Transportprozessleitung der INTERFLUG/PRIKAS/). W. Schmah and S. Beeck (Gesellschaft für Internationalen Flugverkehr mbH, Berlin, East Germany). *Technisch-ökonomische Information der zivilen Luftfahrt*, vol. 16, no. 5, 1980, p. 273-297. In German.

The automated airline management system PRIKAS is divided into seven subsystems. The flight guidance subsystem, which uses a radar data computer, vouchsafes national security and conflict-free flight paths, secures regular and on-time departures and arrivals and follows flight paths. The traffic handling subsystem clears passengers

and baggage, determines the number of passengers, makes available all necessary information for the coordination of traffic handling and control of automatically receiving and dispatching messages. The flight sale subsystem handles the sale of the tickets on the basis of automatically available information, receives reservations, gives information about flight connections and analyzes statistics. The spare part supply subsystem handles automated parts supply from the central warehouse, prepares orders and calculates consumption and cost. The flight preparation subsystem used simulators to train personnel. D.K.

**A81-28745 # Wire communication systems and equipment at airports (Sistemy i oborudovanie provodnoi svyazi aeroportov).** V. A. Ignatov, S. M. Pauk, Iu. M. Kiktenko, G. F. Konakhovich, and M. V. Novikov. Moscow, Izdatel'stvo Transport, 1980. 400 p. 87 refs. In Russian.

Various types of transmission systems at airports are considered, including power transmission, communication cables, transmission lines and communication channels, multichannel communication, telephony, pulse communication systems, telegraphy, data transmission systems, facsimile transmission, and systems for the magnetic recording, reproduction, and display of data. The design, classification, and application of these systems are described; and attention is given to the power supply of these systems. B.J.

**A81-28759 # Aircraft radar equipment and its operation (Radiolokatsionnoe oborudovanie samoletov i ego ekspluatatsiya).** A. P. Tikhonov. Moscow, Izdatel'stvo Transport, 1980. 246 p. 10 refs. In Russian.

Basic design principles are reviewed for three types of aircraft radar equipment: panoramic radar, Doppler meters of velocity and drift, and airborne ATC transponders. Theoretical principles concerning the navigation functions and operation of these instruments are discussed. Attention is given to the design of several particular systems: the DISS-13 Doppler meter, the UVD SOM-64 ATC transponder, and the Groza-154 panoramic radar. B.J.

**A81-28760 # Aircraft thrust augmentors of ejector type (Aviatsionnye ezhektornye usiliteli tiagi).** V. G. Enenkov, A. L. Kliachkin, V. S. Korotkov, and V. M. Suprun. Moscow, Izdatel'stvo Mashinostroenie, 1980. 136 p. 75 refs. In Russian.

The use of ejector-type thrust augmentors in V/STOL aircraft applications is examined. A classification and analysis of multinozzle thrust augmentor systems are given, and the physical principles of augmentor operation are reviewed. The thermodynamic efficiency of the process is considered, and methods of increasing the efficiency of the ejector systems are investigated. The results of an experimental study of the thrust augmentors are also provided. L.S.

**A81-28942 Coupled bending-torsion vibrations of rotating blades of asymmetric aerofoil cross section with allowance for shear deflection and rotary inertia by use of the Reissner method.** K. B. Subrahmanyam, S. V. Kulkarni (Regional Engineering College, Kurukshetra, India), and J. S. Rao (Indian Institute of Technology, New Delhi, India). *Journal of Sound and Vibration*, vol. 75, Mar. 8, 1981, p. 17-36. 22 refs. Research supported by the University Grants Commission.

Theoretical natural frequencies and modal shapes of the first five modes of vibration are presented for a rotating blade of asymmetric aerofoil cross section, with allowance for shear deflection and rotary inertia. Frequency equations for a rotating blade with asymmetry in one place are developed by using the Ritz process, in two ways: namely, by proceeding according to the Reissner method and according to the classical potential energy method. In both cases shape functions for the bending moment, shearing force, twisting moment, bending slope, elastic twist and deflection are developed in series form. The results obtained are compared with those existing in the literature; it is found that the Reissner method approach yields more rapid convergence than does the classical potential energy method. (Author)

**A81-28943 \* An experimental study of transmission, reflection and scattering of sound in a free jet flight simulation facility and comparison with theory.** K. K. Ahuja, H. K. Tanna, and B. J. Tester (Lockheed-Georgia Co., Marietta, Ga.). *Journal of Sound and Vibration*, vol. 75, Mar. 8, 1981, p. 51-85. 10 refs. Contract No. NAS3-20050.

When a free jet (or open jet) is used as a wind tunnel to simulate the effects of flight on model noise sources, it is necessary to calibrate out the effects of the free jet shear layer on the transmitted sound, since the shear layer is absent in the real flight case. In this paper, a theoretical calibration procedure for this purpose is first summarized; following this, the results of an experimental program, designed to test the validity of the various components of the calibration procedure, are described. The experiments are conducted by using a point sound source located at various axial positions within the free jet potential core. By using broadband excitation and cross-correlation methods, the angle changes associated with ray paths across the shear layer are first established. Measurements are then made simultaneously inside and outside the free jet along the proper ray paths to determine the amplitude changes across the shear layer. It is shown that both the angle and amplitude changes can be predicted accurately by theory. It is also found that internal reflection at the shear layer is significant only for large ray angles in the forward quadrant where total internal reflection occurs. Finally, the effects of sound absorption and scattering by the shear layer turbulence are also examined experimentally. (Author)

**A81-28984 Simple methods of determining stress intensity factors.** D. P. Rooke (Royal Aircraft Establishment, Farnborough, Hants., England), F. I. Baratta (U.S. Army, Army Materials and Mechanics Research Center, Watertown, Mass.), and D. J. Cartwright (Southampton, University, Southampton, England). *Engineering Fracture Mechanics*, vol. 14, no. 2, 1981, p. 397-426. 81 refs.

A prerequisite for any fracture mechanics analysis of a cracked structure, is a knowledge of the stress intensity factor at the tip of the crack. Many methods are available for evaluating stress intensity factors, but if the structural configuration is complex, they are usually costly in time and money. This paper describes some simpler approximate methods which are both quick and cheap. Their use is illustrated by examples typical of aerospace applications, e.g., cracks at holes and cracks in stiffened sheets. The errors introduced into calculations of residual static strength and fatigue lifetimes by the use of such approximations are acceptable for many practical cases: They are usually no greater and often smaller than those due to uncertainties in other parameters such as service loads, material toughness, etc. (Author)

**A81-28989 Low cycle fatigue of René 77 at elevated temperatures.** S. D. Antolovich, E. Rosa (Cincinnati, University, Cincinnati, Ohio), and A. Pineau (Paris, Ecole Nationale Supérieure des Mines, Evry, Essonne, France). *Materials Science and Engineering*, vol. 47, Jan. 1981, p. 47-57. 13 refs. Grant No. AF-AFOSR-76-2952.

The study determined the low cycle fatigue (LCF) behavior at 927 C of a nickel-base superalloy, René 77, which is currently being used for jet engine applications. Composition and heat treatment data are summarized in table form. Results of metallographic tests, using optical microscopy, scanning electron microscopy, and transmission electron microscopy are presented. A comparison of the damage mechanisms is given. The high temperature LCF properties of René 77 can be presented by a Coffin-Manson plot, which shows a higher fatigue ductility than is observed in a short-term tensile test. Two distinct cracking processes were observed: grain boundary initiation and transgranular-intergranular crack propagation. The grain boundaries contained numerous M23C6 carbides. The effect of the environment was shown to be substantial and an interaction between environmental damage and the deformation mode was proposed. It was concluded that, all other factors being equal, materials with the highest response stress in a strain-controlled LCF test would be most susceptible to environmental attack. K.S.

**A81-29001** Exact solutions of the equations of motion of a gyro horizon compass. Iu. K. Zhibanov. (*Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela*, vol. 15, Mar.-Apr. 1980, p. 11-18.) *Mechanics of Solids*, vol. 15, no. 2, 1980, p. 1-7. 6 refs. Translation.

**A81-29016** Roll stabilization of flight vehicles by means of rollerons. V. N. Onikiichuk and A. M. Formal'skii. (*Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela*, vol. 15, May-June 1980, p. 20-29.) *Mechanics of Solids*, vol. 15, no. 3, 1980, p. 19-27. 12 refs. Translation.

The equations of motion for a flight vehicle with a 'rolleron' stabilization system are developed. The simplifying assumption of a hinge moment equal to the gyroscopic moment is not employed. The stability of the system is investigated for the case of dry and viscous friction in the axis of rotation of the aileron. O.C.

**A81-29029** Is it safe - The safety assessment of aircraft systems. III - The use of probability methods. W. Tye and T. Lloyd. *Aircraft Engineering*, vol. 53, Mar. 1981, p. 2-4.

Probability methods used in the assessment of aircraft systems safety are briefly described. Among the issues to be considered in arriving at estimates of Mean Time Between Failures (MTBF) are the differences between series and parallel systems, the common as opposed to the cascade failure modes that result from a multiplication of components, the majority vote technique of multiplexed system reliability assessment, the effects of system flight hours, and system sensitivity to error. O.C.

**A81-29030** Design for economy. P. A. Marks (Rolls-Royce, Ltd., Derby, England). *Aircraft Engineering*, vol. 53, Mar. 1981, p. 11-15.

A detailed report is presented on operational costs reduction measures taken in recent years by high-bypass turbofan engine manufacturers. The measures are grouped into three major categories: (1) the reduction of fuel consumption for prolonged periods of service operation, (2) improvement of hardware reliability, both in the engine and in its accessories, and (3) through the optimization of repairability, the prolongation reliable operating life. Stress is placed throughout on the application of these economy principles to the development of the RB211 turbofan engine, for which specific fuel consumption reductions of 6.4% have already been achieved. O.C.

**A81-29051** International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Symposium sponsored by ICAS, AIAA, UNESCO, et al. Edited by P. A. Paranjpe and M. S. Ramachandra (National Aeronautical Laboratory, Bangalore, India). Bangalore, National Aeronautical Laboratory, 1981. 557 p.

The symposium focused on the operation, maintenance, and diagnostics of turbine engines, advanced and hybrid systems, turbine cooling, instrumentation, combustor design problems, materials, vibration and flutter, cascade flow, and compressors. Papers are included on the environmental aspects of aircraft emissions, a new breed of an air breathing engine, discrete hole film cooling of turbine blades, some fundamental aspects of flame stabilization, and numerical computations of compressible steady cascade flows. V.L.

**A81-29052 \* #** The future of aeronautical propulsion. W. L. Stewart (NASA, Lewis Research Center, Cleveland, Ohio). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. KN-1 to KN-11.

This keynote address discusses some of the future challenges and opportunities confronting aeronautics where propulsion is a key factor. The discussion covers various aircraft types including commercial transports, general aviation and military aircraft and identifies propulsion technology required to accommodate further advancements in these types of aircraft. This is then followed by a

discussion of some of the emerging technologies that, if properly exploited, will have significant effect on the engines of the '90's. Some comments on further advancements in the traditional technologies are also included. (Author)

**A81-29053 #** Effectiveness of turbine engine diagnostic systems. C. E. Chamblee, H. S. Hinds, Jr., and L. T. Barnes (ARO, Inc., Arnold Engineering Development Center, Arnold Air Force Station, Tenn.). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 02-1 to 02-10. 7 refs.

Recent implementation of on-condition maintenance concepts for turbine engines has spurred the development of engine diagnostic systems for both military and commercial applications. These concepts, which involve monitoring engine health and continuing engine operation as long as health limits are not exceeded, are intended to replace maintenance concepts of periodic inspections, maximum operating times, and engine overhauls at fixed intervals. The purpose of any engine diagnostic system is to predict, detect and diagnose engine failures in an operational environment; however, the system is equally effective for use in recommending economical component replacement/modification to minimize engine overhaul costs. Once the basic functional requirements for a particular engine application have been identified, the specific hardware and software necessary to achieve these requirements are designed and developed. It then becomes necessary to assess the effectiveness of the diagnostic system design in meeting the functional requirements. Diagnostic system design development philosophy is discussed. Also, this paper addresses some of the factors which can and will effect diagnostic system effectiveness. Some specific examples of the use of diagnostic systems and diagnostic concepts are also presented. (Author)

**A81-29054 #** Engine performance monitoring systems expansion on Alitalia aircraft. B. Signori and F. Traversa (Alitalia, Rome, Italy). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 03-1 to 03-10.

The Alitalia engine condition monitoring system is described. The expansion of the onboard data acquisition and recording systems is discussed and the relevant hardware and software is reviewed. Examples of engine vibration monitoring techniques are provided, and analog and digital tracking usages are illustrated. The gas path parameters which enable engine modular performance analysis and early detection of performance degradation are considered. The maintenance cost and fuel consumption savings stemming from the expanded engine monitoring program are also discussed. L.S.

**A81-29055 #** Contribution to the improvement of the classical method of maintenance of aeroengines. A. A. Badr and M. T. El Mayah (Military Technical College, Cairo, Egypt). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 06-1 to 06-5.

In order to minimize time losses involved in the maintenance of aircraft engines, it is proposed to improve conventional maintenance procedures by early fault detection through priority technical inspection (PTI) and by combining the module-replacement approach with conventional maintenance techniques. It is estimated that by applying the PIT, the serviceability is increased by 8.9%, while the combined module-replacement and conventional approach increases the serviceability by 7.4%. V.L.

**A81-29056 #** Environmental aspects of aircraft emissions - A review and current assessment. R. C. Oliver (Institute for Defense Analyses, Arlington, Va.). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical

Laboratory, 1981, p. 07-1 to 07-10. 71 refs. FAA-supported research.

The environmental effects of aircraft emissions at cruise altitudes and ground level are surveyed. A significant number of SST aircraft may lead to emission effects resulting in a redistribution of ozone with altitude, with ozone increasing in the lower stratosphere and decreasing in the upper stratosphere. The total ozone column would be slightly decreased with 20 km injections, and slightly increased with 17 km injections. Subsonic aircraft may already be significantly increasing the NO(x) content of the atmosphere in the 6-14 km region in northern mid-latitudes and may be increasing the total ozone column. For aircraft at airports, the effects seem to be marginally significant relative to existing air quality standards at present levels of emissions. L.S.

**A81-29057 # Analysis of vibration related failures in aero turbo-shaft engines.** K. Srinivasa and M. L. Sidana (Hindustan Aeronautics, Ltd., Engine Div., Bangalore, India). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 08-1 to 08-5.

The paper discusses the vibration related failures encountered during service operations of helicopter mounted turboshaft engines. The main objective of the study is to identify the type of impending failures that could be revealed in the form of measurable excessive vibrations by introduction of periodical vibration monitoring as a diagnostic tool. Problems identified in this category include bearing failures, rear bearing oil feed pipe line failures, excessive rear bearing arm play, labyrinth seal rub, and coupling sleeve wear. The paper also discusses the factors contributing to such failures and the steps taken to reduce their rate of occurrence. The paper concludes that besides taking remedial measures in the form of design/manufacturing improvements to avoid recurrence of such failures, introduction of inservice periodic vibration monitoring would be an additional logical choice to identify the impending failures before these can result in serious flight safety hazards. The choice of equipment for such an exercise and the results of vibration checks are also discussed.

(Author)

**A81-29058 # Helicopter transmission fatigue life.** K. F. Fraser and C. N. King (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 09-1 to 09-10. 6 refs.

A Royal Australian Navy program aimed at providing safe life estimates for the critical components of helicopter main rotor gearboxes is discussed. The torque spectra instrumentation used is described along with the methods for obtaining gear fatigue data. A third generation instrument presently undergoing flight trials computes and displays fatigue life expenditure up to four critical gears, and also indicates total flying time. Basic transmission torque data are automatically printed at the termination of each flight. It is noted that this development is leading toward the fatigue life monitoring of individual components. L.S.

**A81-29059 # Investigation into the vibration of the starter gearbox of an aircraft turbine engine.** P. D. McFadden (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings.

Bangalore, National Aeronautical Laboratory, 1981, p. 10-1 to 10-10.

Investigations into the vibration of the starter gearbox in military aircrafts, and the vibration testing of the entire Australian aircraft fleet, are discussed following a number of failures of these gearboxes. A review is given of the two methods of the manufacturer's vibration tests, the filter and the spectrum methods. The spectra were separated into three categories: (1) spectra with broad, prominent upper or lower sidebands about the meshing vibration component showed the necessity of urgent replacement of the

gearbox, (2) spectra containing small but discernible sidebands showed the gearbox to be in need of replacement and (3) spectra with no sidebands discernible above the background vibration level showed the box to be satisfactory. Research using computer graphics is continuing in order to locate the exact source and nature of the resonance. An overspeed protection device was recommended for the starters. D.K.

**A81-29060 # Technology pays off on the AV-8B.** C. C. Cassmeyer (McDonnell Aircraft Co., St. Louis, Mo.). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 12-1 to 12-6.

The integration of new technology into the AV-8A vectored thrust V/STOL concept is described. The modifications to the AV-8A include an improved inlet with a larger auxiliary inlet system, lift improvement devices, and a larger supercritical wing made of composites. The resulting improvements in performance and weapons system effectiveness have been demonstrated in the YAV-8B prototype flight program. L.S.

**A81-29061 # The sweep finite element method for calculating the flow field and performance of supersonic ejector nozzles.** H. Shen, C. Dong, T. Shyur, and M. Kee (Northwestern Polytechnical University, Xian, Shaanxi, Communist China). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 15-1 to 15-5. 15 refs.

A new method is presented to calculate the performance and the flow field of supersonic ejector nozzles. As compared with previous methods, this method treats the subsonic, transonic and supersonic flow of the nozzle with a more general and yet simpler calculating procedure. By means of the method of weighted residuals, the governing differential equations of aerodynamics are transformed directly into nonlinear algebraic equations. Certain optimization techniques are used for solving these equations. By starting from the upstream side and by considering each element as an independent calculating unit, the calculation is carried on from one element to another. Computations were made and the numerical results are compared with those of the method of characteristics and with appropriate experimental data. Comparison shows that they are in fairly satisfactory agreement. (Author)

**A81-29062 # Noise attenuation and associated thrust increase of turbojet engines through hyper-mixing ejector shrouds.** B. H. Goethert (Tennessee, University, Tullahoma, Tenn.). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 17-1 to 17-11. 5 refs.

Exhaust ejector configurations are optimized with regard to noise attenuation without losses of thrust. It is shown that exhaust ejectors with hypermixing nozzles are capable of significant reductions of jet noise at an ejector area equal to 2.67 times the primary nozzle area to sound pressure levels of up to 16 dB with a simultaneous thrust augmentation of 1.26. The ejectors with hypermixing nozzles demonstrate superior performance compared with conventional nozzles and generate these performance improvements using considerably shorter lengths. The entrainment of wake air into the ejector can also substantially improve ejector performance at low flight velocities. L.S.

**A81-29063 # Jet noise suppression for low bypass engines - Have we reached a dead end.** S. L. Sarin (Fokker-VFW, Schiphol, Netherlands) and W. B. de Wolf (Nationaal Lucht- en Ruimtevaartlaboratorium, Emmeloord, Netherlands). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 18-1 to 18-6. 7 refs.

The use of a silencer nozzle-ejector to reduce the jet noise of the RB 183 engine is investigated by means of a model-scale inflight

simulation experiments. The investigations were performed in an anechoic wind tunnel on a one-tenth scale model using a conical nozzle with a diameter of 60 mm. The hot core jet was simulated by decomposed hydrogen peroxide giving an effective total temperature of about 825 K. It was found that jet noise reduction with an ejector nozzle is possible only at a considerable loss of thrust. A more viable method of reducing the subsonic jet noise of low bypass engines was found in the application of internal mixers which also improved thrust performance. L.S.

**A81-29064 # Flowfield studies of dump combustors.** R. S. Boray (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, Ohio) and C. Chang (Wright State University, Dayton, Ohio). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 22-1 to 22-8. 9 refs.

A parametric study was conducted of the fluid dynamic nature of a straight coaxial sudden-expansion dump combustor with varying step heights. Tests were performed with two pairs of inlet and nozzle combinations (5.08 cm and 7.62 cm each). Fuel was simulated by argon injection, and gas concentrations of the simulated fuel-air mixture were measured using an on-line mass spectrometer. It is shown that the cold flow mixing data gives a good indication of the performance of mixing limited combustors. The results are also applied to the validation of the mathematical models developed for the analysis of the ramjet combustor. L.S.

**A81-29065 # An approach to ramjet trajectory simulation test.** S.-S. Chiang (China Precision Machinery Corp., Beijing, Communist China). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 23-1 to 23-7.

A ground simulation test (conducted in a direct-connect test facility) has been developed for a ramjet trajectory in the boost and the ascent phases. The simulation process is presented in detail. The test results have been verified in flight tests with very good results. The inlet flow parameter, the overshoot problem, the temperature and pressure simulation and the exhaust environment parameters are also covered. K.S.

**A81-29066 # Performance analysis of primary and secondary systems of a rocket ramjet engine burning fuel-rich metallized propellants.** V. Ramanujachari, S. Krishnan, K. S. Padiyar, R. Natarajan, and M. G. Gupta (Indian Institute of Technology, Madras, India). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 24-1 to 24-10. 13 refs.

Ramjet due to its high specific impulse, high speed and continuous thrust suits uniquely the atmospheric missiles. The major milestone of ramjet technology development in the last two decades is the conception and demonstration of integrated rocket-ramjet for missile applications. This paper details a relatively simple one-dimensional analysis of a solid propellant rocket-ramjet engine for its equilibrium operating performance. In the analysis the following aspects are considered: (1) axisymmetric inlet performance, (2) complex chemical equilibrium composition for the burning metallized fuel rich solid propellant of primary motor, (3) consequent multiphase flows, and (4) mixing and diffusion of air and fuel rich burnt products and subsequent reaction in the secondary chamber. A typical case study is presented using the analysis. (Author)

**A81-29067 # Preliminary experimental study of combustion in the solid rocket-ramjet.** D.-M. Chen, Y.-Y. Qi, Y.-Y. Li, and Z.-Z. Sun (China Precision Machinery Corp., Beijing, Communist China). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 25-1 to 25-8.

The secondary combustion in a 150-mm-diameter cylindrical combustor for the solid rocket-ramjet was investigated. The effect of factors such as combustor length, nozzle type of primary rocket, air/fuel equivalence ratio, pressure of primary rocket chamber, and others on the performance of the combustor and the engine was examined. During the test, three aluminum- or aluminum/magnesium-loaded fuel-rich composite propellants were used. The W-Re thermocouples were used to measure the total temperature of gas and its radial distribution. Experimental results were compared with the theoretical performance of the engine. (Author)

**A81-29068 # Air augmentation of rockets for low speed application.** S. A. Fisher (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) and R. D. Irvine (Department of Defence, Weapons Systems Research Laboratory, Adelaide, Australia). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 26-1 to 26-8. 12 refs.

A continuing investigation aims to determine the increase which can be achieved in the thrust of a solid fueled rocket at static or very low speed flight conditions, by air augmentation of the propulsive jet with a non-afterburning ejector. Experiments in which unheated, high pressure air acts as the primary fluid in a range of model ejectors have been combined with rocket firings to determine the effects of a number of variables on ejector thrust. Presently available results suggest that significant thrust augmentation is available, and further performance gains should result from resolution of some remaining uncertainties. (Author)

**A81-29069 # Factors affecting afterbody drag.** W. H. Schofield (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 28-1 to 28-10. 23 refs.

The propulsion system afterbody can contribute a significant proportion of the total drag in both aircraft and rocket propelled vehicles. The present work is restricted to wind tunnel investigations of factors affecting subsonic drag of axisymmetric afterbodies. Results of studies in which the same factors (Mach number, Reynolds number, and wind tunnel blockage) were varied have been previously published by several authors. However no one appears to have satisfactorily separated the individual effects of these factors, and this is the aim of the present study. Explanations for the observed changes in afterbody pressure distribution are offered and some comparisons between the present and previous results are made. (Author)

**A81-29070 # A new breed of an air breathing engine.** M. Berchtold (Zürich, Eidgenössische Technische Hochschule, Zurich, Switzerland). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 29-1 to 29-6. 6 refs.

Small shaft power gas turbines of less than 200 HP are presently unavailable for light aircraft propulsion. The use of recuperators, as proposed for improving the efficiency in automotive small gas turbines, is not feasible for aircraft installation. The wave pressure exchanger 'Comprex', used in connection with conventional turbomachines, promises to become an efficient and compact powerplant. Its low weight and the absence of vibrations makes it well suited for the propulsion of light aircrafts. The 'Comprex' is capable to utilize high peak cycle temperatures due to the fact that the rotor is exposed to both the air to be compressed and the hot gas to be expanded. Theoretical and experimental experience accumulated with wave pressure exchangers applied to Diesel engines supercharging, allows to predict the performance of this new turbine engine. The expected efficiency of .27 is competitive with present aircraft piston engines. (Author)



**A81-29071 # Sudden expansion injection for ram-rockets.** J. B. Greenberg and Y. M. Timnat (Technion - Israel Institute of Technology, Haifa, Israel). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 29a-1 to 29a-9. 17 refs.

A numerical method for computing the elliptic internal reacting flows is presented. It uses an operator splitting method for the conservation of species equations that permits their usually problematic integration to be performed in a two-step process. For the first nonreacting stage the algorithm of Gosman et al (1969) is utilized, while the form of the second reacting stage enables it to be recast as a set of ordinary differential equations. The latter are solved for different geometrical configurations using Gear's (1971) method for combating the stiffness that is frequently associated with problems involving realistic chemical kinetic schemes. The experimental results reported are in good agreement with the numerical predictions. A strong recirculation zone is found close to the injection point. The geometry affects both chemical reaction and flow stability: 45 deg injection causes an increase in the mean flow rate, which is not evident at 90 deg. Perpendicular injection appears to be more stable than 45 deg entrance, which is also dependent on the exact configuration. (Author)

**A81-29072 # Aerodynamic calculation of turbine stator cascades with curvilinear leaned blades and some experimental results.** Z.-C. Wang, S.-K. Lai, and W.-Y. Shu (Harbin Institute of Technology, Harbin, Communist China). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 30-1 to 30-9. 15 refs.

Flow calculations are made and compared for high aspect ratio turbine stator cascades with radial, straight swept, and curvilinear swept blades. It is shown that the component of the blade force along the blade height can be controlled in the case of the curvilinear swept blade, with two consequences: (1) a reduction or even elimination of the inward crossflow in the boundary layer near the hub, and (2) a suction of the boundary layer from both ends of the blades into the main stream zone. Experimental results verify the achievement of higher efficiencies by means of this blade geometry. O.C.

**A81-29073 # Discrete hole film cooling of turbine blades.** N. Hay (Nottingham, University, Nottingham, England). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 33-1 to 33-7. 36 refs.

Data and prediction methods for discrete hole film cooling are reviewed from the turbine blade design point of view. The review covers methods of data generation, methods of data presentation, the use of data in the design situation, and, the methods of prediction. The main parameters governing film cooling performance are discussed with the emphasis placed on the relative importance of each on the resultant film cooling effectiveness. The effect of the pertinent parameters on heat transfer coefficient and on the discharge coefficient of film cooling holes is also covered. Areas where data is needed and where contributions can be made are itemised. It is concluded that although a considerable amount of data on film cooling has been reported in the literature there is still no general accurate method of prediction of cooling effectiveness for the working turbine blade situation. (Author)

**A81-29074 # Film cooling performance by injection through discrete holes.** A. A. M. El'Elwany and M. M. A. El'Naar (Ain Shams University, Cairo, Egypt). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 34-1 to 34-8. 9 refs.

The present study includes film cooling measurements along a flat plate exposed to a main stream of air, with injection of a

secondary air through discrete holes. Injection occurred through two different sets of hole configurations of 5 and 10 mm diameters, each arranged in a single row, spaced at two different distances, and producing two different injection angles, namely 30 and 45 deg to the horizontal, respectively. Experimental results are presented for the velocity profiles, the temperature profiles, film cooling effectiveness, and the local heat transfer coefficient, given for two velocity ratios of the injected air velocity to the main stream velocity of 0.5 and 1, respectively. Comparisons are also made with some previously developed theoretical models for slot film cooling. The limitation of the application of such a theoretical model is emphasized. (Author)

**A81-29075 # Film cooling performance of liner cooling devices.** B. R. Pai and R. Lakshminarayanan (National Aeronautical Laboratory, Bangalore, India). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 35-1 to 35-7. 11 refs.

Data on the film cooling performance of several liner cooling devices are obtained over the range of velocity and density ratios relevant to gas turbines. Among the devices with tangential injection, the wiggle strip device and the machined ring with skirt construction provide the most effective film cooling. The addition of a skirt to the wiggle strip may improve its performance in the lower velocity range. The lowest effectiveness was obtained with the splash cooling arrangement which gives effective cooling of the slot lip at the expense of downstream performance. Of the discrete hole injection devices tested, the dimpled hole construction gives a significantly better performance than normal injection over a wide range of velocity ratios. L.S.

**A81-29076 # Turbine blade cooling research at the von Karman Institute for Fluid Dynamics.** P. Ligrani and F. A. E. Breugelmans (Institut von Kármán de Dynamique des Fluides, Rhode-Saint-Genève, Belgium). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 36-1 to 36-14. 32 refs.

A research program dealing with the problems of turbine blade cooling has been in progress at the von Karman Institute for the past eight years. A review of this program is presented beginning with studies of heat transfer to boundary layers developing over flat plates with and without film cooling, where the effects of Mach number, Reynolds number, free stream turbulence level and pressure gradient are investigated. Convex curved wall flows are also examined when the convective processes are influenced by film cooling. These basic studies are complemented with investigations applied to turbine blade cooling directly. On the sidewall of a turbine cascade with and without film cooling, local heat transfer rates are studied as they are influenced by secondary flow effects. Blade surface heat transfer rates as affected by changes in Reynolds number, Mach number and free stream turbulence level are also discussed. Results are presented using heat transfer coefficients, adiabatic and isothermal effectiveness and Stanton number and Nusselt number correlations. (Author)

**A81-29077 # The analytical ferrograph - Some factors affecting deposit formation.** N. L. Atkin (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) and G. G. McVea (Department of Defence, Materials Research Laboratories, Melbourne, Australia). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 37-1 to 37-7.

Wear debris examination is widely practiced as one of the possible indications of the condition of operating machinery. A ferrograph has been designed to support this technique by magnetically separating and displaying wear particles on a glass substrate according to size. Experiments have demonstrated that the pattern of wear particle deposition is dependent on the rate of flow of the sample along the substrate, the oil viscosity, the substrate angle and barrier width, and the sample delivery angle. These parameters have

been optimized to provide particle separation needed for morphological examination of samples used in the experiments, but for other oil types, trial and error methods may be necessary to achieve optimum results. Preliminary experiments with quantitative ferrography showed that it was possible to improve repeatability of measurements by modification of the standard preparation methods; however, sample contamination by insoluble organic material was difficult to control and adversely affected the measurement of wear. (Author)

**A81-29078 # A digital technique for the analysis of the response of compressor/duct systems in unsteady flow.** D. K. Das (Cranfield Institute of Technology, Cranfield, Beds., England) and R. E. Peacock. In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings.

Bangalore, National Aeronautical Laboratory, 1981, p. 39-1 to 39-12. 8 refs. Research supported by the Ministry of Defence (Procurement Executive).

A method is presented to aid the analysis and understanding of the response of a compressor/duct system to an input flow with superimposed time-wise unsteadiness which may have planar irregularities. In using a digital technique to evaluate the statistical functions of power spectral density, ordinary coherence, multiple coherence and partial coherence it becomes possible to establish the characteristics of the input and output signals and assess their inter-relationship. Further by a process of mathematical isolation of all but one input signal, the dependence of the output upon that of an input signal may be established. As an example, data from an experiment in which an aircraft type three stage compressor embedded in long ductwork was subjected to a superimposed inlet unsteadiness comprising a series of pressure waves, were analyzed. The level of coherence between the individual signals and the system output and an unaccounted residual in the output were evaluated. A subfundamental frequency and its second harmonic that was identified in the system was tentatively interpreted as the signature of a rotating stall regime of operation. (Author)

**A81-29081 # Analysis of a reverse flow, annular combustion chamber.** F. M. Joubert (Council for Scientific and Industrial Research, Institute for Aeronautics and Systems Technology, Pretoria, Republic of South Africa) and H. V. Hattingh (Stellenbosch University, Stellenbosch, Republic of South Africa). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings.

Bangalore, National Aeronautical Laboratory, 1981, p. 43-1 to 43-8. 19 refs.

A largely one-dimensional analytical program has been developed for application to annular reverse flow gas turbine combustion chambers. The work is based on a similar program of the late sixties applicable to parallel or through flow chambers, with some improvement, as well as simplification, where considered justifiable. The nature of the flow in such chambers does, however, necessitate a completely different and highly iterative approach to the solution of the relevant equations. Some theoretical results are presented. (Author)

**A81-29082 # Cyclone combustors in low emission gas turbine applications.** N. Syred (University College, Cardiff, Wales) and A. C. Styles. In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings.

Bangalore, National Aeronautical Laboratory, 1981, p. 44-1 to 44-8. 10 refs. Research supported by the Science Research Council of England.

The design of fuel efficient gas turbine combustors with low pollutant emission and multi-mode operation has proved difficult in the past and resulted in a compromise between emission and performance. With tighter emission control in the future and the necessity to utilize alternate fuel sources, further difficulties are expected to arise with the present types. This paper describes recent work on cyclone combustors capable of flame movement (modulation) by the variation of mixture ratio. The aerodynamics and flame characteristics of three modes of combustion are presented with

particular reference to the flame movement mechanism. Such performance, in terms of system adaptability and low pollutant emission over a wide operating range, is discussed with respect to the requirements of future gas turbine combustors. Their use with low calorific value gases and liquid fuels of high carbon/hydrogen ratios is highlighted. (Author)

**A81-29083 # Factors limiting turbine inlet temperatures.** B. Sjoblom (Volvo Flygmotor AB, Trollhattan, Sweden) and J. Odgers (Université Laval, Quebec, Canada). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings.

Bangalore, National Aeronautical Laboratory, 1981, p. 46-1 to 46-6. 6 refs.

Improvements in the materials and design of nozzle guide vanes and turbines suggest that present values of turbine inlet temperatures may be extended. This paper discusses other, sometimes less obvious, limitations such as the effects of chemical dissociation, pollutant considerations (CO and NO(x)) and the effects of film cooling. Considerations of dissociation assume that a 1 percent loss in combustion efficiency is the maximum which could be tolerated. Limitations set for pollutants correspond approximately to the United States EPA recommendations. Film cooling restrictions are particularly pertinent to premixed-prevaporized combustors. With the assessment of all of these factors, it seems likely that a reasonable turbine inlet temperature for future engines will be of the order of 2000 K, regardless of combustor type. (Author)

**A81-29084 # Fresh mixture entrainment in a jet curtain flameholder.** K. Sridhara and M. S. Chidananda (National Aeronautical Laboratory, Bangalore, India). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings.

Bangalore, National Aeronautical Laboratory, 1981, p. 47-1 to 47-6. 9 refs.

An experimental investigation has been carried out to determine the fresh mixture entrainment in the recirculation zone of a jet curtain stabilized flame. The entrainment values were obtained indirectly by determining the fuel-air ratios at lean blow-off limits of the flame. These experiments were carried out in a rectangular duct, of cross section 203.2mm x 152.4mm, at a pressure of 9x10 to the 4th N/sq m. Jets from the flameholder were injected perpendicular to the mainflow which consisted of a premixed mixture of aviation kerosene and air. Similar tests were also carried out on a 30 deg V-gutter which produced a geometric blockage of 0.375. The results obtained indicate that the entrainment fraction of the jet curtain flameholder is about 0.20 while that of the V-gutter, of comparable blockage, is only about 0.04. (Author)

**A81-29086 # A comparison of two droplet models for gas-turbine combustion chamber flows.** W. P. Jones and J. J. McGuirk (Imperial College of Science and Technology, London, England). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings.

Bangalore, National Aeronautical Laboratory, 1981, p. 49-1 to 49-8. 21 refs. Research supported by Rolls-Royce, Ltd.

The calculation of liquid-fuelled gas-turbine combustor flows necessitates the use of a mathematical model describing the behavior of the fuel spray. The advantages and disadvantages of two droplet models are discussed in the present paper and the results of calculations using both models are compared against measurements of the flow in an axisymmetric kerosene-fuelled combustor which uses a swirling air stream to stabilise combustion. The first model allows no slip between droplets and surrounding gas and solves transport equations for the mass fraction of droplets in a finite number of size ranges; turbulent transport of the droplets is accounted for however via an eddy diffusivity calculated using a constant turbulent Prandtl/Schmidt number and a two-equation turbulence model. The second model uses Eulerian transport equations for the gas-phase and Lagrangian equations for individual droplet motion and evaporation. Again a finite number of size-ranges is considered, and a droplet tracking calculation allows the interaction between the two phases to be taken into account; slip

between droplets and gas is thus now allowed, but turbulent droplet transport is ignored. The results of calculations are compared on the basis of measured velocity and temperature fields, and the predicted droplet evaporation rates are also examined. (Author)

**A81-29087 # The combustion modelling of swirling flows for gas turbine combustors.** T. C. Claypole and N. Syred (University College, Cardiff, Wales). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 50-1 to 50-7. 18 refs. Research supported by the Science Research Council.

Velocity and temperature data are presented in the paper for a free swirling gas flame. From these a model is derived for the gas turbine combustion chamber consisting of well stirred and plug flow reactors. The implications for the formation of NO(x) are briefly discussed. It is concluded that flame stabilisation is achieved by the formation of well stirred regions, not by the large scale recirculation of hot products. It is essential to optimize these well stirred regions to reduce NO(x) emissions. (Author)

**A81-29089 # The effect of oxygen concentration distribution on altitude relighting performance of a turbo-jet engine combustor.** Y.-F. Wu, Z.-X. Huang, S.-M. Wang, and Y.-Z. Wang (Academia Sinica, Institute of Engineering Thermophysics, Beijing, Communist China). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 53-1 to 53-9. 12 refs.

**A81-29090 # High temperature metal matrix composites for gas turbines.** L. O. K. Larsson (Volvo Flygmotor AB, Trollhattan, Sweden). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 54-1 to 54-8. 9 refs. Research supported by the Air Materiel Department.

Tungsten wire reinforced iron or nickel alloys offer a significant potential for improvements in temperature capability compared to super-alloys. The mechanical properties of this type of materials were investigated to provide a basis for the evaluation of the potential advantages and possible difficulties to be expected in the application of such material. A fabrication process for turbine blades has been developed. Blade design is discussed in connection with the high composite density and wire/matrix interaction problems. The effects on performance of an advanced aero-engine by introduction of composite turbine components are analyzed. (Author)

**A81-29091 # Photoelastic investigation of stress distribution around inclined cut-outs in gas-turbine components subjected to in-plane and bending loads.** R. Padmanabhan, K. Ramachandra, V. Maruthi, and B. J. Raghunath (Gas Turbine Research Establishment, Bangalore, India). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 55-1 to 55-11. 6 refs.

Stress concentration factors at critical points of inclined cut-outs in rotating gas turbine sealing rings, for which no published data is available, have been evaluated by photostress and stress-freezing techniques. Modified models, which eliminated the influence of fillets and clamping holes, were used for the study of stress-concentration factors at different angles of inclination of the cut-out, varying from 30 to 90 deg and for different cut-out sizes, varying from 5 to 15 mm in diameter. Stress-concentration factors based on the nominal stress obtained from a model without any cut-out varied from 5.3 to 1.5. The values decreased with increase in the angle of inclination but increased with increase in the size of the cut-out. The influence of design parameters on the stress-concentration factor has also been studied. (Author)

**A81-29093 # Investigation of the squeeze film bearing on two-spool turbo-fan engine.** W.-M. Li, S.-Z. Chen, Z.-Q. Wu, and Y.-B. Sun (Shenyang Aeroengine Research Institute, Shenyang, Communist China). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 57-1 to 57-6. 8 refs.

A test program for the squeeze film bearing was developed which is based on the analysis of the factors effecting the performance of the bearing. Three squeeze film bearings designed for a turbofan engine are described and the results from both rig test and engine test are presented in the paper. The effects of the film clearance, with and without the centering spring, on the vibration characteristics of the engine under different unbalance levels of the rotor and different oil pressure are investigated. The test results indicate that the vibration of the engine could substantially be reduced by means of the squeeze film bearing. Some design and test problems are also discussed in the paper. The test work presented is a valuable investigation for developing squeeze film bearing under the condition of lacking in the informations which are necessary for designing these bearings. (Author)

**A81-29094 # Experimental verification of unsteady aerodynamic models of supersonic unstalled flutter.** S. Fleeter (Purdue University, West Lafayette, Ind.). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 58-1 to 58-10. 20 refs.

The rotor blade modeling concepts and time-variant aerodynamic cascade experimental techniques relevant to supersonic unstalled turbofan flutter are presented. Correlations of the resulting torsion and translation mode cascade data with predictions obtained from unsteady aerodynamic models of supersonic unstalled flutter are then utilized to verify these theoretical models and to determine their viability as predictive techniques for turbomachine applications. (Author)

**A81-29097 # Reduction of strut induced rotor blade vibration with the modified stator setting angles.** S. Yokoi, S. Nagano (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan), and Y. Kakehi (Japan Defense Agency, Technical Research and Development Institute, Tokyo, Japan). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 61-1 to 61-7.

An investigation was conducted to reduce strut-induced rotor blade vibration by modification of the stator setting angle in the neighborhood of the struts. The performance of a two-stage fan in which thick struts were located behind the second-stage stator row was investigated experimentally. The fan was tested with various second-stage stator setting angle distributions. The vibration level of second-stage rotor blades and the pressure distribution upstream of second-stage stator were investigated and compared with the results with uniform stator setting angle. In the case of optimal stator setting angle distribution, it was confirmed that the vibration level of second-stage rotor blades was reduced to 40% of that of the uniform setting angle. A pressure distortion prediction was also conducted and compared with the experimental results. The simplified calculation method can be effective to approximately predict the strut-induced pressure distortion upstream of the stator row both with the uniform stator setting angle and with the modified stator setting angle. (Author)

**A81-29098 \* # The influence of gyroscopic forces on the dynamic behavior of rotating blades.** F. Sisto and A. T. Chang (Stevens Institute of Technology, Hoboken, N.J.). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 62-1 to 62-8. NASA-supported research.

## A81-29099

The question of divergent oscillatory stability of an axial turbomachine blade when the bladed rotor system is subjected to a forced precessional motion is studied by using two simplified models of the blade. The simplest (lumped) model is a point mass restrained by three orthogonal linear springs attached to the rotor. An improved distributed parameter model represents the blade by a uniform cantilever beam with bending in one plane. In both instances instability is shown to be strongly dependent upon the ratio of blade root radius to blade length and the magnitude of the rotor spin relative to the nonrotating blade natural frequency for realistic values of precession rate. Results are presented on augmented Campbell diagrams. Implications for design and operation are drawn as are the characteristics of needed future studies. (Author)

**A81-29099 # On the solution of Navier Stokes equations of the flow in turbomachines.** A. M. Elzahaby (Military Technical College, Cairo, Egypt). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 64-1 to 64-7. 8 refs.

Attempts have been made at the solution of the three-dimensional flow in an axial flow compressor stage. Considering the Navier-Stokes equations, a radial equilibrium equation describing the radial variation of absolute axial velocity component in the axial gaps of turbomachines is derived for steady axially symmetric compressible viscous flow considering the annulus taper angle and meridional streamline curvature. The new concept here is the evaluation of the friction force considering the viscous terms of the Navier-Stokes equations. As a result of these analysis, a nonlinear second-order differential equation is obtained which is solved on a computer by use of the finite difference technique. The necessary boundary conditions for solution of the differential equation are given by zero velocity at root and tip sections. Experimental verification of the analytical results is given together with the evaluation of the method in comparison with either available theoretical method. (Author)

**A81-29100 # Numerical computation of compressible steady cascade flows.** H.-H. Frihauf (Stuttgart, Universität, Stuttgart, West Germany). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 65-1 to 65-7. 8 refs.

Potential and Euler solutions are presented for inviscid flows through cascades with wedge-type leading and trailing edges. All the numerical two-dimensional and three-dimensional finite difference solutions were obtained by using quasi-streamline meshes which were nonorthogonal, rectangular, body-conforming, and edge-adapted. With a local mesh refinement in the leading edge region, the quasi-streamline meshes can be used to compute flows through cascades with blunt-nosed profiles. Three-dimensional potential solutions for absolute-irrotational subcritical rotor flows with spanwise varying blade circulation are also described. L.S.

**A81-29101 # The axial velocity density ratio and the axial velocity density distribution in axial flow compressors and cascades.** J. Starke (Bayer AG, Leverkusen, West Germany). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 66-1 to 66-15. 25 refs. Research supported by Bayer AG.

In general the flow at the axial flow compressor blade sections is quasi-two-dimensional with the axial velocity density ratio (AVDR) differing from unity. With different compressor configurations there are also connected different axial velocity density distributions (AVDD), which together with the AVDR influence the aerodynamic performance of the blade sections considerably. As cascade tests still represent the most reliable source of information on the aerodynamic parameters of axial flow compressor blade sections, it is demonstrated, how to simulate not only the AVDR but also a prescribed AVDD by use of a conventional cascade arrangement. Based on experimental and theoretical cascade investigations a set of

correlations is given for an easy and accurate determination of the turning angle, the reference minimum-loss inlet angle and the blade loss including AVDR as well as AVDD effects. (Author)

**A81-29102 # Evaluation of blade element performance of compressor rotor blade cascades in transonic and low supersonic flow range.** H.-A. Schreiber and H. Starken (Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt, Institut für Antriebstechnik, Cologne, West Germany). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 67-1 to 67-9. 10 refs.

Experimental investigations on two compressor rotor blade cascades with MCA-profiles have been performed in the transonic Mach number range 0.8-1.2. The incidence angle range between choking and stalling was analyzed. Some selected results show the influence of the inlet Mach number, the inlet flow angle and the axial velocity density ratio on the cascade performance. Additionally, one example of transonic flow field analysis by laser velocimetry is presented. (Author)

**A81-29105 # The accuracy of mean-stream-line method in subsonic and transonic regions.** R.-X. Cai (Academia Sinica, Institute of Engineering Thermophysics, Beijing, Communist China). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 71-1 to 71-8. 12 refs.

It is noted that the mean-stream-line method has undergone significant development in China. With this method, the two-dimensional flow is solved by correcting a certain one-dimensional flow of the so-called main stream line. Thus, the errors that arise will connect with the deviation of the calculated flow from one-dimensional flow, that is, the turning (curvature) and the converging (acceleration) of the flow, as well as the width of the calculated flow passage. From this standpoint, the error equations are obtained through a comparison between the analytical solutions of this approximate method and the rigorous solutions of the standard pure turning flow and pure converging flow. It is found that this method is effective for most cases of modern subsonic and transonic turbine and compressor cascades. C.R.

**A81-29106 \* # Analysis of turbulent boundary layer on cascade and rotor blades of turbomachinery.** B. Lakshminarayana and T. R. Govindan (Pennsylvania State University, University Park, Pa.). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 72-1 to 72-14. 19 refs. Grant No. NSG-3266.

The momentum integral technique for predicting the boundary layer growth in three-dimensional flow has been extended to include the entrainment equation as the closure model. The numerical solution is compared with the cascade, inducer, compressor, and fan rotor blade data from various sources. The agreement is found to be excellent in all cases, with the exception of the separated flow. Both the momentum thickness and the limiting streamline angle predicted from this analysis compare well with the measured data for a rotor blade. The technique is extremely useful in engineering design, analysis, and performance prediction. (Author)

**A81-29107 # Analysis of the difficulties in high performance compressor data reduction.** J. Paulon (ONERA, Châtillon-sous-Bagneux, Hauts-de-Seine, France) and D. Dehondt (Turbomeca, S.A., Bizanos, Pyrénées-Atlantiques, France). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 73-1 to 73-8. Research sponsored by the Direction des Recherches, Etudes et Techniques.

It is noted that flow traverses made in different sections of an axial flow compressor are of great use in obtaining a detailed understanding of the flow. These measurements are in most cases

redundant, and it is possible to control the validity of some of them. The difficulty of measuring certain parameters correctly and the need to use other measurement techniques in order to validate a data reduction method are illustrated in the case of two advanced axial flow compressors. C.R.

**A81-29108 \* #** Effects of solid particles suspended in fluid flow through an axial flow compressor stage. W. Tabakoff and C. Balan (Cincinnati, University, Cincinnati, Ohio). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 75-1 to 75-10. 7 refs. Grant No. NSG-3218.

An approximate method for calculating the flow properties of gas-particle mixture flowing over blades in a cascade is studied. Using an analytical method, the solid particle trajectory and location of collisions between the solid particles and the blade surfaces are determined. In addition an experimental investigation of the trajectories and velocities of solid particles suspended in a fluid passing through an axial flow compressor cascade was performed. The cascade blades were made of 2024 aluminum alloy and the solid particles used were quartz sand with average diameter of 165 microns. The following parameters were investigated: blade pressure distribution, and total pressure loss coefficient, both depending on the degree of erosion. In addition, a theoretical estimation of the blade erosion is compared with the experimental data. (Author)

**A81-29109 #** Particulate flow in centrifugal compressors used in helicopters. A. F. Abdel Azim (Egyptair, Cairo, Egypt) and M. I. I. Rashed (Cairo, University, Cairo, Egypt). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 76-1 to 76-10. 21 refs.

This paper presents a theoretical approach for analyzing particulate flow in centrifugal compressors used in helicopters as part of their gas turbines. For high velocity and low concentration levels, particles are assumed to have no influence on the gas flow properties. Thus the gas flow characteristics are obtained as if no particles were suspended using 'streamline curvature method'. Next, the particle motion (location, velocity and acceleration) is obtained through the numerical integration of the 3-D equations of a particle superimposed on the gas flow field. The particle trajectories of certain particle cloud composed mainly of silicon dioxide and aluminum oxide particles are traced. These trajectories revealed that the areas which are subjected to more impacts and consequently more likely to be eroded are the hub surface near the exit, blade pressure surface and shroud surface near the inlet. (Author)

**A81-29110 #** Effects of Coriolis on the turbulent field inside centrifugal impellers. J. P. Bertoglio, J. P. Melinand, J. Mathieu, and G. Charnay (Lyon, Ecole Centrale, Ecully, Rhône, France). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 77-1 to 77-11. 9 refs.

The effects of rotation on turbulence are studied. A theoretical study provides information on the behavior of turbulence in rotating frame, in particular the one point closures are discussed. Experimental results are obtained in a testing centrifugal impeller by using embarked hot-wire probes. Qualitative agreement with computation is good. (Author)

**A81-29111 #** Model for axial compressors operating with water ingestion. T. Tsuchiya and S. N. B. Murthy (Purdue University, West Lafayette, Ind.). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 78-1 to 78-10. 29 refs. Contract No. F33615-78-C-2043.

Water ingestion into compressors may occur because of various circumstantial reasons. It is then of interest to establish the changes in the compressor performance and the behavior of the engine. A

simple model has been developed for compressor performance calculation that takes into account aero-thermo-mechanical processes in blade passages on a parametric basis. Droplet centrifuging and inter-phase heat and mass transfer processes become of critical importance. The scalability of compressor and engine performance is also discussed with respect to effects of size, initial conditions and operational parameters. (Author)

**A81-29112 #** Three dimensional flow in annular diffusers with two vortex distributions at entry. B. E. L. Deckker (Saskatchewan, University, Saskatoon, Canada) and J. Iwamoto (Tokyo Electrical Engineering College, Tokyo, Japan). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Bangalore, National Aeronautical Laboratory, 1981, p. 63-1 to 63-9. 9 refs.

A finite difference scheme known as the fluid-in-cell method has been used to simulate rotationally symmetrical, inviscid, compressible flows in straight-wall annular diffuser geometries. The flows are adiabatic and reversible. At entry the flows are in radial equilibrium and the swirl velocity distributions conform either to a free vortex or to solid rotation. Four generic geometries have been identified and the results obtained with these diffusers are presented and discussed. Variations due to changes in geometrical details are compared. (Author)

**A81-29113 #** Comparisons of model and flight testing with respect to hot gas reingestion and debris ingestion during thrust reversal. W. Kurz (Messerschmitt-Bölkow-Blohm GmbH, Munich, West Germany). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Symposium sponsored by ICAS, AIAA, UNESCO, et al. Bangalore, India, National Aeronautical Laboratory, 1981. 10 p.

Various methods of optimizing thrust reverser operation by controlling the hot gas reingestion boundary of a target type reverser system on a military aircraft are treated. For some methods, windtunnel investigations were carried out and their results are briefly discussed. Both the model simulation and the flight test experiments are described along with the comparisons of their results. Experiments were also performed to investigate debris ingestion. These results were compared with the results of hot gas reingestion. The most evident result of all investigations presented is the good agreement of hot gas reingestion results comparing the scaled model with the aircraft. (Author)

**A81-29114 \* #** Flow separation in inlets at incidence angles. A. K. Jakubowski (Virginia Polytechnic Institute and State University, Blacksburg, Va.) and R. W. Luidens (NASA, Lewis Research Center, Cleveland, Ohio). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Symposium sponsored by ICAS, AIAA, UNESCO, et al. Bangalore, India, National Aeronautical Laboratory, 1981. 13 p. 13 refs. Grant No. NSG-3073.

Wind-tunnel pressure data and flow pictures obtained for two two-dimensional inlet models have been examined to study the internal flow structure and separation at large incidence angles. The inlet models were 12-in. high (diffuser exit height) and had internal contraction ratio of 1.21 and 1.17. They were tested at low forward speeds over a wide range of throat Mach numbers (inlet mass flow rates) and angles of incidence. Characteristic features of the internal flow such as a drastic change of pressure gradient near the highlight, local separation bubbles and shock/boundary-layer interactions have been indicated and discussed. For a few specific cases, the experimental surface pressure distributions have been compared with theoretical predictions. (Author)

**A81-29115 #** Transpiration air cooled turbine blade - A technology for future generation aircraft and industrial gas turbine engines using coal or coal derived fuels. R. Raj (City College, New York, N.Y.). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Symposi-

um sponsored by ICAS, AIAA, UNESCO, et al. Bangalore, India, National Aeronautical Laboratory, 1981. 25 p. 34 refs.

An insight to the design and development of the transpiration air cooled turbine blade concept is presented in this paper. The technology considerations include a discussion of the blade concept, heat transfer effectiveness, thermo-aerodynamics, erosion-corrosion-deposition resistance characteristics and technology status. In recent developments the transpiration cooling concept achieved operation at high temperatures of 3000 F (1650 C) while offering protection for the turbine blades from damage due to particulate emission from a combustion process simulating the use of coal or coal-derivatives. The technology achieved in this field is at a stage where nations dependent on importation of oil and natural gas can consider the shift to coal or other forms of fossil fuels for operating highly efficient gas turbines in a combined cycle for electric power generation. (Author)

**A81-29117 # Development and validation of computational flow analysis for design of inlets and nozzles.** E. Tjonneland and S. F. Birch (Boeing Military Airplane Co., Seattle, Wash.). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Symposium sponsored by ICAS, AIAA, UNESCO, et al. Bangalore, India, National Aeronautical Laboratory, 1981. 12 p. 15 refs.

The use of numerical fluid flow analysis in the design of inlet and nozzle installations is briefly outlined and compared with the present experimental based design procedure. Emphasis, in this paper, is primarily on a discussion of the role of experimental work in the development of numerical design methods. A few examples of recent numerical calculations of inlet and nozzle related flows are first described. This is followed by a discussion of the three different types of experiments: technology experiments, validation experiments and basic experiments, and their use in the development of numerical calculations methods. (Author)

**A81-29118 # A look at comprehensive engine/airframe integration for high performance aircraft.** E. Hienz and W. Schreiber (Messerschmitt-Bölkow-Blohm GmbH, Munich, West Germany). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Symposium sponsored by ICAS, AIAA, UNESCO, et al. Bangalore, India, National Aeronautical Laboratory, 1981. 9 p. 5 refs.

In view of the design development coordination difficulties posed by multinational consortium cooperation in advanced military aircraft ventures (and especially the separate development of airframe and engine designs), a method for the comprehensive consideration of aerodynamic, structural, mechanical, and functional requirements is proposed. A series of interfaces between the major elements of the engine/airframe system and their cost and performance goals are defined, which will permit dispersed design teams to systematically consider the aspects of the system for which they are responsible without loss of overall cohesiveness. O.C.

**A81-29119 # The engineering basis for the application of life cycle cost or supportability criteria to gas turbine engines.** R. L. Spencer (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, Ohio). In: International Symposium on Air Breathing Engines, 5th, Bangalore, India, February 16-22, 1981, Proceedings. Symposium sponsored by ICAS, AIAA, UNESCO, et al. Bangalore, India, National Aeronautical Laboratory, 1981. 7 p.

The need to integrate engine 'life function' (defined as the design features needed to maintain performance and flexibility for a given use and maintenance environment) with other criteria in the development of military powerplants is discussed. The need to achieve a balance between the performance capabilities of an engine and its support costs is stressed, and a design process with which to implement that requirement is outlined. O.C.

**A81-29144 # The effect of jet non-uniformity on the lift of an augmentor wing.** V. Q. Tang (W. L. Wardrop and Associates, Ltd.,

Canada) and J. Tinkler (Manitoba, University, Winnipeg, Canada). *Canadian Aeronautics and Space Journal*, vol. 26, 4th Quarter, 1980, p. 312-321. 6 refs.

A potential flow solution was formulated for a non-uniform jet augmentor wing by dividing the jet into several uniform layers, and numerical results were obtained for the special case of two layers of equal thickness. It was found that a higher lift was developed for a given primary jet momentum coefficient when the lower layer of the jet had a higher velocity than the upper part. The method's incomplete representation of the flow at the start of the jet is compensated for by its simplicity and practicality. O.C.

**A81-29145 # Comparison of two methods for the reduction of free decaying data in aircraft flutter tests.** B. H. K. Lee and D. J. Jones (National Aeronautical Establishment, Ottawa, Canada). *Canadian Aeronautics and Space Journal*, vol. 26, 4th Quarter, 1980, p. 322-335. (NAE-LTR-HA-43)

A least-squares curve fit and the moving-block technique developed by Lockheed-California Company for determining damping values and frequencies from free decaying data are described. In comparing these two methods, the data used are generated numerically for a two degree of freedom system with various amounts of noise added. The effects of sample length and number of data points on the results obtained from the least-squares fit method have been studied. Also, the effect of block size in the moving-block technique has been investigated, although not in great detail. Case studies of these two methods show the moving-block technique to be more accurate, but both methods become increasingly poor as the noise level is increased. (Author)

**A81-29150 The next combat aircraft.** R. D. Boot (British Aerospace, Warton Div., Preston, Lancs., England). *Aerospace (UK)*, vol. 8, Apr. 1981, p. 10-14.

The performance requirements and economic factors that will influence the design of the next generation of multirole combat aircraft are discussed in light of historical experience since the decade of 1930-40. Operational effectiveness, structural materials options and the range of possible configurations are discussed in light of the need to restrain cost escalation trends. Particular stress is placed on the reconciliation of air-to-air combat and air-to-ground operations, in such matters as sensors and armaments, on the relative advantages of VTOL and VSTOL capabilities, and on the need to improve reliability and maintainability in spite of increases in system complexity. O.C.

**A81-29197 The influence of flames on the formation of self-excited combustion chamber oscillations (Der Einfluss von Flammen auf die Entstehung selbsterregter Brennkammerschwingungen).** W. Lenz (Karlsruhe, Universität, Karlsruhe, West Germany). *Brennstoff-Wärme-Kraft*, vol. 33, Mar. 1981, p. 98-102. 10 refs. In German.

A method for the measurement of the flame frequency behavior is presented. The frequency behavior of enclosed and free-burning turbulent, premixed flames in the frequency range between 1 and 500 Hz is examined. A frequency behavior model is given which presents an accurate reproduction of the measured values being dependent on the frequency. The transmission behavior of a jet combustion engine and an elongated cylindrical combustion chamber is then derived. The flame frequency behavior and the Nyquist criterion are used to discuss the stability of the whole combustion system. D.K.

**A81-29201 # A method for obtaining shockless transonic flows past two-dimensional airfoils whose profiles are partially modified from a given arbitrary profile.** M. Nakamura (National Aerospace Laboratory, Chofu, Tokyo, Japan). *Japan Society for Aeronautical and Space Sciences, Transactions*, vol. 23, Feb. 1981, p. 195-213. 6 refs.

A combination of the direct and inverse methods for obtaining shockless transonic flows over two-dimensional airfoils is described.

While putting an arbitrary airfoil in a region of free-stream flows with comparatively large Mach number will normally yield shock waves, it is the purpose of the paper to show how shockless transonic flows may be obtained through partial modification of the given arbitrary airfoil. The method presented may be extended to predict or analyze the flows over a full, three-dimensional wing. O.C.

**A81-29205 # Sensitivity reduction in aircraft control systems by double Perfect Model Following.** T. Okada, M. Kihara, and N. Kuroda (Defense Academy, Yokosuka, Kanagawa, Japan). *Japan Society for Aeronautical and Space Science, Aircraft Symposium, 17th, Nagoya, Japan, Nov. 28, 1979.* *Japan Society for Aeronautical and Space Sciences, Transactions*, vol. 23, Feb. 1981, p. 247-257. 6 refs.

A concept of parameter sensitivity reduction by Perfect Model Following (PMF) techniques, using the principle of open- and closed-loop sensitivity in optimal control systems, is introduced and examined. A double PMF technique is then devised to realize further sensitivity reductions, and simulations based on it are made for both a simple numerical example and a flight control problem. Comparisons between double PMF systems having different model parameters show that smaller absolute values of roots and larger control matrix values contribute greatly to the sensitivity reduction. O.C.

**A81-29207 Airborne emergency hospital.** R. Merl (Lockheed Aircraft Service Co., Ontario, Calif.). *Lockheed Horizons*, Spring 1981, p. 26-30.

A design history and introduction to operational capabilities are presented for the Emergency Hospital Aircraft, a self-sufficient medical care facility enclosed in a C-130H Hercules aircraft. The aircraft can take off and land from rough airstrips of as little as 4000 to 5000 feet in length to provide medical treatment at remote destinations as well as en route to more extensive base hospital facilities. The aircraft incorporates such features as self-sustained generation of electrical power and heat and air conditioning for up to three days, an emergency treatment and examination area, operating theater, intensive care ward, and a telecommunications system to provide radio communication between the aircraft and a base hospital. The system is specifically designed for use in Third World nations with inaccessible desert or jungle regions. O.C.

**A81-29208 In-flight research - At low cost.** M. W. M. Jenkins (Lockheed-Georgia Co., Marietta, Ga.). *Lockheed Horizons*, Spring 1981, p. 32-39.

An overview is presented of a flight test program in which a manned, jet-powered sailplane has been used in conjunction with several remotely controlled 0.3-scale research vehicles for advanced aerodynamics technology research. Among the concerns of the program have been the effects of wing spanwise blowing, laminar flow control by slot-suction methods, leading-edge insect strikes, vortex diffusers, airframe noise, command augmentation, and fiber-optic flight controls. A description is also given of the fully integrated ground monitoring facilities at which test aircraft telemetry is gathered, reduced, and analyzed. O.C.

**A81-29301 # Calculation of the aerodynamic characteristics of aircraft with jet mechanization (Raschet aerodinamicheskikh kharakteristik samoleta so struinoi mekhanizatsiei).** V. G. Akent'ev and V. V. Guliaev. *Aviatsionnaia Tekhnika*, no. 4, 1980, p. 3-6. In Russian.

A numerical method is developed for calculating the steady-state aerodynamic characteristics of an aircraft with jet flaps. The flow past the aircraft and the jet are modeled as a system of oblique horseshoe-shaped vortices, and the problem is solved in the linear formulation for an incompressible medium. B.J.

**A81-29304 # Low-speed wind tunnels with deformable walls (Ob aerodinamicheskikh trubakh malykh skorosti s deformiruemy-mi granitsami).** A. A. Gruzdev. *Aviatsionnaia Tekhnika*, no. 4, 1980, p. 23-26. 7 refs. In Russian.

Attention is given to the development of self-streamlining or self-correcting wind tunnels. Linear theory under the assumption of potential flow is used to study the shape of streamline surfaces near a wing of finite aspect ratio moving near a screen. The characteristics of flow macrostructure in the wake are analyzed; and it is shown that, in contrast to the case of two-dimensional flow, it is not possible to streamline the walls of the tunnel in the absence of a vortex wake in the case of three-dimensional flow. B.J.

**A81-29305 # Basic problem of the analytical design of aircraft gas turbine engines. II (Osnovnaia zadacha analiticheskogo proektirovaniia aviatsionnykh gazoturbinnnykh dvigatelei. II).** Iu. V. Kozhevnikov, V. O. Borovik, V. S. Ivanov, V. A. Talyzin, I. N. Agliullin, and Iu. V. Meluzov. *Aviatsionnaia Tekhnika*, no. 4, 1980, p. 27-32. In Russian.

The paper presents results of the analytical optimization of the basic thermogasdynamic parameters of the cycle and the characteristic areas of the air path of a turbojet bypass engine; the optimization criterion is minimum engine-mass and minimum fuel required for a given flight distance. The multimode character of engine operation is analyzed. B.J.

**A81-29307 # Evaluation of the influence of local disturbances of flow past trailing and leading flaps from wind tunnel data on a rectangular wing section (K otsenke vliianiia mestnykh narushenii obtekaniia zakrytkov i predkrytkov po dannym ispytaniu v aerodinamicheskoi trube otseka priamougol'nogo kryla).** A. I. Matiazh, V. A. Sterlin, A. B. Kuznetsov, V. V. Isaev, A. A. Shapiro, and E. M. Ksenofontova. *Aviatsionnaia Tekhnika*, no. 4, 1980, p. 38-42. 5 refs. In Russian.

Equipment for the suspension and control of leading and trailing flaps was tested in a low-speed wind tunnel. The influence of the control mechanisms, and, of their positions along the wing span and in the cross section, on the integral aerodynamic characteristics of a rectangular wing was evaluated. It is found that local disturbances of flow past leading and trailing flaps produce a significant reduction of lift and an increase of drag. B.J.

**A81-29310 # The use of carbon-reinforced plastic in the construction of a deflector and a stabilizer (O primeneni ugleplastika v konstruktii deflektora i stabilizatora).** B. N. Kornev, P. I. Guseva, and V. A. Tikhomirov. *Aviatsionnaia Tekhnika*, no. 4, 1980, p. 72-74. In Russian.

Glass-graphite-plastic composite materials were used in the construction of aircraft deflectors and stabilizers. This paper reviews the details of construction, and examines static-load testing results for both deflector and stabilizer. B.J.

**A81-29311 # Synthesis of gyrostabilizer state evaluation system under unknown perturbations (Sintez sistemy otsenki sostoi-niia girostabilizatora pri neizvestnykh vozmushcheniakh).** A. A. Leporskii. *Aviatsionnaia Tekhnika*, no. 4, 1980, p. 74-76. In Russian.

**A81-29312 # Concerning the motion of a piloted aircraft (K voprosu o dvizhenii vedomogo samoleta).** A. A. Novad. *Aviatsionnaia Tekhnika*, no. 4, 1980, p. 79-81. In Russian.

Equations are derived for the three-dimensional motion of an aircraft and are solved analytically for the initiation of banking flight. The solution describes the effect of the specific wing load on the normal acceleration overloading of the aircraft. It is noted that the danger of a spin increases with increasing specific load. B.J.

**A81-29313 # Experimental study of the snap-through oscillations of an empennage (Eksperimental'noe issledovanie kolebani-i proshchelkivaniia opereniia).** V. A. Pavlov, F. Sh. Khakimullin, A. Ia. Gur'ianov, and M. I. Gershtein. *Aviatsionnaia Tekhnika*, no. 4, 1980, p. 81-84. 5 refs. In Russian.

The snap-through oscillations of a rectangular-planform empennage model were studied in a subsonic wind tunnel. The aim of the



study was to isolate the snap-through oscillations from all other possible oscillations in the flow. An analysis of changes of the normal and frontal curvatures of the control surface demonstrate the occurrence of snap-through oscillations. The frontal curvature falls to practically zero in the case of static snap-through. B.J.

**A81-29363 \*** A diagonal form of an implicit approximate-factorization algorithm. T. H. Pulliam (NASA, Ames Research Center, Moffett Field, Calif.) and D. S. Chaussee (Flow Simulations, Inc., Sunnyvale, Calif.). *Journal of Computational Physics*, vol. 39, Feb. 1981, p. 347-363. 16 refs.

A modification of an implicit approximate-factorization finite-difference algorithm applied to partial differential equations is presented. This algorithm is applied to the two- and three-dimensional Euler equations in general curvilinear coordinates. The modification transforms the coupled system of equations into an uncoupled diagonal form that requires less computational work. For steady-state applications, the resulting diagonal algorithm retains the stability and accuracy characteristics of the original algorithm. The diagonal algorithm reduces the storage requirement of the implicit solution process and therefore has an important effect on the application of implicit finite-difference schemes to vector processors. Results are presented for realistic two-dimensional transonic flow fields about airfoils. Computation costs are reduced to 24-34%.

(Author)

**A81-29377** Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, Technical Papers. Part 1. Conference sponsored by AIAA, ASME, ASCE, and AHS. New York, American Institute of Aeronautics and Astronautics, Inc., 1981. 503 p. Price of two parts, members, \$75.; nonmembers, \$100.

The following topics are representative of the conference contents: computation of wind tunnel model deflections, fatigue sensitivity of composite structures for fighter aircraft, the effect of material shortages on the commercial aircraft and engine industries, and the use of flight simulators in developing design load spectra for new aircraft. Also covered are the design and development of the crew model structure for the Space Shuttle Orbiter, low strain creep and aging of aluminum alloy 2219-T87 sheet, the bolt bearing strengths of graphite/epoxy laminates, post first-ply failure fatigue behavior of composites, optimal design of laminated composite shells, nonlinear laminate analysis of metal matrix fiber composites, and the development of thick-walled composite pressure vessels for ultra-high internal pressure. Additional papers cover the design allowables for T300/5208 graphite/epoxy composite materials, a manufacturing cost/design guide for metallic and composite structures, and the cost-effective application of structural technology to the stretched C-141. O.C.

**A81-29378 #** A new method for torsion of shaft with variable diameter using non-orthogonal curvilinear coordinates and its application. M.-H. Li and X.-A. Ren (Academia Sinica, Mechanics Institute, Beijing, Communist China). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, Technical Papers. Part 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 1-6. 5 refs. (AIAA 81-0477)

The equilibrium and compatibility equations for the case of a torsionally stressed shaft with variable circular cross-section are expressed in terms of the divergence and curl, respectively, of two related shear stress vectors. The fact that the divergence and curl of a vector are invariants for different coordinate systems is used to derive the equilibrium and compatibility equations in arbitrary, non-orthogonal curvilinear coordinates. Numerical calculations are presented for a shaft having an analytical solution as well as for a gas turbine shaft having a complicated contour line. O.C.

**A81-29381 \* #** Computation of wind tunnel model deflections. S. C. Mehrotra (Vigyan Research Associates, Inc., Hampton,

Va.) and B. B. Gloss (NASA, Langley Research Center, Hampton, Va.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, Technical Papers. Part 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 33-37. 7 refs. Contract No. NAS1-16114. (AIAA 81-0482)

The experimental deflections for a transport type solid wing model were measured for several single point load conditions. These deflections were compared with those obtained by structural modeling of the wing by using plate and solid elements of Structural Performance Analysis and Redesign (SPAR) program. The solid element representation of the wing showed better agreement with the experimental deflections than the plate representation. The difference between the measured and calculated deflections is about 5 percent. (Author)

**A81-29382 #** Statistical crack growth in durability and damage tolerant analyses. J. N. Yang (George Washington University, Washington, D.C.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, Technical Papers. Part 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 38-49. 21 refs. Contract No. F33615-77-C-3123. (AIAA 81-0492)

Statistical analyses of crack growth rate test results are presented for 7475-T7351 aluminum specimens subjected to loading spectra typical of fighter aircraft. It is found that two crack growth rate parameters are highly correlated statistical variables, which are fitted reasonably well by the lognormal distribution. It is demonstrated that the statistical approach to the analysis of crack growth damage accumulation in durability and damage tolerance studies provides a good basis from which to consider phenomena in which crack growth variability is important. The effect of crack growth variability on the economic life of a durability-critical component is illustrated, and comparisons of damage accumulation analyses with F-16 fighter full-scale durability tests are presented. O.C.

**A81-29383 #** Fatigue sensitivity of composite structure for fighter aircraft. L. L. Jeans, G. C. Grimes, and H. P. Kan (Northrop Corp., Aircraft Div., Hawthorne, Calif.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, Technical Papers. Part 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 50-60. 8 refs. (AIAA 81-0495)

A spectrum sensitivity study was conducted on chordwise splices in a fighter aircraft composite wing. Composite-to-metal bolted and bonded joints were used to experimentally determine their fatigue sensitivity to spectrum loading and environmental content. Fiber dominated bolted joints were not sensitive to any of the parametric spectrum load variations in any of the environments used. By contrast the step-lap bonded joints were sensitive to many of the parametric spectrum load variations and environmental exposures used. However, the bolted joints were significantly heavier than the bonded joints. Control and monitoring of materials and processes variables through an extensive quality assurance program was found to be indispensable for isolating parametric effects. (Author)

**A81-29386 #** Material shortages - Effect on the commercial aircraft industry. A. L. Wingert (Boeing Commercial Airplane Co., Seattle, Wash.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, Technical Papers. Part 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 79-85. 13 refs. (AIAA 81-0508)

The structural materials used in the production of commercial aircraft are reviewed with their prime sources and the long-range outlook for their continued availability. The primary structural materials of concern are aluminum, iron, titanium, manganese, cobalt, and chromium. Chromium and manganese, which primarily come from Africa, are considered the most critical since they have no real replacements in their application in plating and steel production,

respectively. Substitute materials and processes are becoming available for many of the aircraft applications, such as powder metallurgy techniques that allow the production of near-net-shape, low-waste products. (Author)

**A81-29387 # Material shortages - Effect on the aircraft engine industry.** M. A. Siegel (United Technologies Corp., Government Products Div., West Palm Beach, Fla.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, Technical Papers. Part 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 86-88. 6 refs. (AIAA 81-0509)

To meet demands for improved performance and durability, aircraft gas turbine engines have been designed to include the most advanced materials and manufacturing processes. Recently this trend was disturbed due to shortages of materials, increases in costs, and extended lead times. The causes of these problems vary from dependence upon foreign sources for materials, to industrial capacity limitations. Recognizing this to be a long range problem, engine design and manufacturing philosophies are changing. Material substitution, improved manufacturing processes, and scrap reclamation are among the basic approaches. Design engineers are being motivated to an awareness of latest materials and processes trends and acceptable cost tradeoffs. (Author)

**A81-29388 \* # IPAD applications to the design, analysis, and/or machining of aerospace structures.** C. L. Blackburn, A. R. Dovi, W. L. Kurtze (Kentron International, Inc., Hampton, Va.), and O. O. Storaasli (NASA, Langley Research Center, Hampton, Va.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, Technical Papers. Part 1.

New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 96-104. 15 refs. (AIAA 81-0512)

A computer software system for the processing and integration of engineering data and programs, called IPAD (Integrated Programs for Aerospace-Vehicle Design), is described. The ability of the system to relieve the engineer of the mundane task of input data preparation is demonstrated by the application of a prototype system to the design, analysis, and/or machining of three simple structures. Future work to further enhance the system's automated data handling and ability to handle larger and more varied design problems are also presented. (Author)

**A81-29389 # Use of flight simulators in developing design load spectra for new aircraft.** R. R. Lauridia and D. J. White (Vought Corp., Dallas, Tex.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, Technical Papers. Part 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 105-113. Contract No. F33615-80-C-3205. (AIAA 81-0513)

A plan is defined for the use of simulator-generated time histories of fighter/attack aircraft structural parameters to develop load spectra representative of anticipated aircraft use. F-4E simulator-generated and flight-generated structural parameter data are investigated in order to verify the feasibility of the plan. It is concluded that the simulator is an efficient means of producing structural trend data related to unique flight characteristics, such as the use of maneuvering flaps, direct side force capability, and the incorporation of thrust vectoring nozzles. The plan will also evaluate the flight load environment of aircraft flying air-to-air missions, especially combat maneuvering, and it is adaptable to air-to-ground missions. O.C.

**A81-29396 # Bolt bearing strengths of graphite/epoxy laminates.** S. J. Kong (Northrop Corp., Aircraft Div., Hawthorne, Calif.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, Technical Papers. Part 1.

New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 158-165. (AIAA 81-0544)

The bearing strengths of graphite/epoxy laminates have been

studied as design allowables for analyzing mechanical fastener joints. Bearing specimens were fabricated from woven fabric and unidirectional graphite/epoxy prepregs of 3501-6 matrix. The specimens were statically tested for bearing strengths at various temperatures. Test data were expressed as yield bearing strengths and ultimate bearing strengths and statistically analyzed. Tests in a hot/wet environment indicated the graphite/epoxy laminates are a forgiving material with a bearing deformation similar to metal counter-parts. Thus, a relatively even load-sharing capability can be expected in a multibolt mechanical joint in a hot/wet environment. (Author)

**A81-29399 \* # Sensitivity of optimum solutions to problem parameters.** J. Sobieszczanski-Sobieski (NASA, Langley Research Center, Loads and Aeroelasticity Div., Hampton, Va.), K. M. Riley (Kentron International, Inc., Hampton, Va.), and J.-F. Barthelemy. In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, Technical Papers. Part 1.

New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 184-205. 15 refs. (AIAA 81-0548)

In an aircraft configuration optimization, the information of interest is the sensitivity of optimal block fuel consumption and wing aspect ratio and area, to variations of required range and payload. The objectives of this study are: (1) to show how the equations capable of yielding the sensitivity derivatives (the sensitivity equations) can be obtained for a constrained optimum regardless of the type of optimization algorithm that was used to arrive at the optimum point, (2) to review the solvability of the sensitivity equations and (3) to report on applications on structural optimization. Numerical examples, which demonstrate the sensitivity analysis, include a tubular column and a three-bar truss for which closed form solutions are obtained, a ten-bar truss that requires the use of a finite element analysis, and a thin-walled beam characterized by strongly nonlinear constraints for local buckling. It is concluded that a practically significant extrapolation accuracy may be obtained for a reasonably broad range of parameter changes; and that accuracy does not depend strongly on the degree of convergence of the optimum solution from which the sensitivity derivatives are obtained. K.S.

**A81-29400 \* # The controlled growth method - A tool for structural optimization.** P. Hajela (Stanford University, Stanford, Calif.) and J. Sobieszczanski-Sobieski (NASA, Langley Research Center, Hampton, Va.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, Technical Papers. Part 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 206-215. 9 refs. Grant No. NGL-05-020-243. (AIAA 81-0549)

An adaptive design variable linking scheme in a NLP based optimization algorithm is proposed and evaluated for feasibility of application. The present scheme, based on an intuitive effectiveness measure for each variable, differs from existing methodology in that a single dominant variable controls the growth of all others in a prescribed optimization cycle. The proposed method is implemented for truss assemblies and a wing box structure for stress, displacement and frequency constraints. Substantial reduction in computational time, even more so for structures under multiple load conditions, coupled with a minimal accompanying loss in accuracy, vindicates the algorithm. (Author)

**A81-29402 # Optimality criterion techniques applied to frames having nonlinear cross-sectional properties.** M. R. Khan (Clarkson College of Technology, Potsdam, N.Y.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, Technical Papers. Part 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 233-241. 10 refs. (AIAA 81-0552)

The optimality criterion method developed in this research is capable of locating the optimal design of WF steel frames with members having complex nonlinear cross-sectional relationships among the area, moment of inertia and the section modulus. The method uses the idea of one most critical constraint to avoid the

calculation of large sets of Lagrange multipliers, and also avoids the scaling procedure normally used in other optimality criterion techniques. Several example structures, designed under stress, displacement and minimum area constraints, demonstrate the efficiency, reliability and the simplicity of the method. Although the method of this research uses the idea of one most critical constraint, the optimal designs presented in this paper have several active constraints. (Author)

**A81-29403 # Shape optimization of plate and shell structures.** M. E. Botkin (GM Research Laboratories, Warren, Mich.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, Technical Papers. Part 1.

New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 242-249. 12 refs. (AIAA 81-0553)

In the past, much of the work done in structural optimization consisted of resizing the members of fixed configuration models. There is, however, a broad class of plate and shell problems in which an additional reduction in mass can be attained by including in the design process the capability for varying the shape of boundaries and the shape and location of cutouts. This additional capability has made it necessary to address other problems such as how to maintain an adequate finite element model, how to define perfectly general shapes which satisfy a number of criteria, and how to impose the proper constraints so that a realistic design results. The shape design capability is demonstrated on practical problems which result in as much as 35 percent weight-savings over a uniform thickness design with fixed boundaries. (Author)

**A81-29405 # Instability of short stiffened and composite cylindrical shells acting under pure bending moments considering prebuckling displacements.** V. Villhart, A. N. Palazotto (USAF, Institute of Technology, Wright-Patterson AFB, Ohio), and C. Bang. In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, Technical Papers. Part 1.

New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 256-261. 6 refs. (AIAA 81-0571)

The bifurcation of a composite shell, a stiffened isotropic shell, and a stiffened isotropic shell with cutouts are studied under a bending prebuckling load with the results to be used in analyzing aircraft fuselage behavior and in designing rocket bodies. The STAGS-C computer program was used, incorporating a finite difference approach to the solution of the eigenvalue problems resulting from variations of the potential energy function for strain in a structure. A linear prebuckling phase was included in the bifurcation analysis. It was concluded that for the most part, the composite shell acts very much like the stiffened shell when one considers a comparison between moment and axial resulting force as length/radius ratio increases. K.S.

**A81-29407 # Study of the crashworthiness of light aircraft structures.** R. C. Tennyson, H. Teichman, A. P. Nanyaro, and G. Mabson (Toronto, University, Toronto, Canada). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, Technical Papers. Part 1.

New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 276-285. 14 refs. Transport Canada Contract No. O1SU-T800-7-7536; Natural Sciences and Engineering Research Council of Canada Grant No. A-9185. (AIAA 81-0574)

An extensive program has been undertaken to investigate the dynamic behavior of fuselage structures subject to various impact conditions. Extensive testing of scale model stiffened aluminum sections has been completed for a wide range of wing loads, angles of incidence and impact velocities. Both vertical drop tests and free-flight impacts using a pendulum gantry have been studied. Test data have been obtained in terms of maximum structural strains, g-loads and high-speed photographs of the dynamic collapse modes. Based on a finite element model, these cases have also been analyzed including elastic/plastic deformation and panel buckling. (Author)

**A81-29419 \* # Historical development of flutter.** I. E. Garrick and W. H. Reed, III (NASA, Langley Research Center, Hampton, Va.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, Technical Papers. Part 1.

New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 381-401. 131 refs. (AIAA 81-0591)

A historical survey of aeroelasticity, and in particular flutter, is given. The instances in which aeroelasticity played a major role in aircraft failure are detailed, and developments taking flutter into account from the days of the early aviation pioneers up to their successors in the 1950's are reviewed. Aerodynamic theories analyzing flutter are also discussed. D.K.

**A81-29420 # An application of the energy release rate concept to crack growth in attachment lugs.** I. J. Zatz (Princeton University, Princeton, N.J.), H. L. Eidinoff, and H. Armen, Jr. (Grumman Aerospace Corp., Bethpage, N.Y.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, Technical Papers. Part 1.

New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 402-415. 21 refs. Research sponsored by the Grumman Advanced Development Program. (AIAA 81-0491)

A numerical method involving a variable multipoint constraint capability is used to determine the energy release rates associated with a propagating crack in straight sided, round-head and square-head attachment lugs. The method, formulated within the framework of finite element procedures, evaluates the changes in energy as a function of changing crack length along a prescribed crack path. A single idealization consisting of conventional quadrilateral finite elements is used in the computations. Results are presented for a variety of geometries and loading cases involving axial, as well as skewed, loadings. Comparisons with other existing analytical and experimental results are made for verification. (Author)

**A81-29424 # Manufacturing cost/design guide /MC/DG/ for metallic and composite structures.** B. R. Noton (Battelle Columbus Laboratories, Columbus, Ohio) and R. R. Preston (USAF, Materials Laboratory, Wright-Patterson AFB, Ohio). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, Technical Papers. Part 1.

New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 445-462. (AIAA 81-0518)

The Air Force 'Manufacturing Cost/Design Guide' (MC/DG) enables airframe designers to conduct trade-offs between manufacturing costs and other design factors. Sections have been developed for sheet metal; mechanically-fastened assemblies; composites; castings; test, inspection, and evaluation (TI&E); and emerging technologies. The man-hour data is presented for base parts and designer-influenced cost elements (DICE) in cost-driver effects (CDE) and cost-estimating data (CED) formats. The MC/DG has been utilized in aerospace companies for trade-offs on aluminum, titanium, and graphite/epoxy fuselage shear panels. The MC/DG is also used for procurement; e.g., castings, and for identifying manufacturing operational sequence candidates for computer-aided manufacturing (CAM) applications. The MC/DG will be available to designers in hard copy and as a computerized manufacturing cost/design system (MC/DS). (Author)

**A81-29427 # The stretched C-14 - Cost effective application of structural technology.** P. W. Horton and R. L. McDougal (Lockheed-Georgia Co., Marietta, Ga.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, Technical Papers. Part 1.

New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 485-498. (AIAA 81-0514)

Cost-effective structural technology was applied to the C-141A aircraft in order to add aerial refueling capability and to stretch aircraft size by 280 inches, thus allowing the loading of 13 rather than 10 pallets. In this way 30 to 50% can be gained in cargo volume and airlift. Structural solutions are discussed for the various

constraints on the airframe modification program. The constraint that there be no increased drag was met by adding a fillet. The constraint that there be no decrease in service life, and even an increase from 30,000 to 40,000 hours, was met by tailoring the fillet to minimize lift due to the stretch weight increase. The constraint of cost minimization was solved by careful application of sound engineering. It is demonstrated that the durability and damage tolerance of the airframe is adequate for a viable modification, and that a reduction of cost from \$1.4 billion in the concept phase for 90 new C-141A's to about \$243 million in the production phase for a 30% increase in cargo volume and added aerial refueling on 271 C-141B's can be achieved. D.K.

**A81-29428 Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2.** Conferences sponsored by AIAA, ASME, ASCE, and AHS. New York, American Institute of Aeronautics and Astronautics, Inc., 1981. 849 p. Price of two parts, members, \$75.; nonmembers, \$100.

Topics discussed include: finite element prediction of damping in structures with constrained viscoelastic layers, analytical tools for simulating large amplitude propellant slosh, static and dynamic characteristics of large deployable space reflectors, Space Shuttle main engine nozzle-steerhorn dynamics, and vibroacoustic modeling for the Space Shuttle Orbiter thermal protection system. Also discussed are attenuation of propeller-related vibration and noise, vibration of cylindrical shells of bimodulus composite materials, the automated application of Ibrahim's time-domain method to responses of the Space Shuttle, a least-squares time-domain method for simultaneous identification of vibration parameters from multiple free-response records, electronic damping of resonances in gimbal structures, and the response of stiffened sandwich panels. Also covered are a self-adaptive algorithm for thermoviscoplasticity, dynamic flight load charts for spacecraft design, nonlinear dynamic phenomena in the Space Shuttle thermal protection system, the application of transonic codes to flutter analysis of conventional and supercritical airfoils, the effect of store aerodynamics on wing/store flutter, in-flight structural dynamic characteristics of the XV-15 tilt rotor research aircraft, and the response characteristics of a linear rotorcraft vibration model. O.C.

**A81-29442 # Attenuation of propeller related vibration and noise.** J. F. Johnston and R. E. Donham (Lockheed-California Co., Burbank, Calif.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 112-121. 17 refs. (AIAA 81-0521)

The potential sources and paths by which the propeller produces structural responses resulting in vibration and noise in the cabin of a transport aircraft are discussed. New low-cost, convenient experimental and analytical techniques are described for evaluating the excitations - propeller airborne pressures on the fuselage shells, slipstream-induced forces on the wing and tail, and oscillatory forces on the propeller. The techniques described make use of ground-determined structural signatures to relate forces with vibrations or noise, and of propeller signatures from flight tests which define the vibroacoustic contributions of individual propellers. Knowing these, the propeller-produced excitation forces can be deduced by the relations shown; design approaches to control the fatigue and vibroacoustic environment can then be enunciated logically.

(Author)

**A81-29445 # Resonance of forwards and backwards vibration mode of impeller with gyroscopic effect.** N. Hagiwara, K. Kikuchi (Hitachi, Ltd., Mechanical Engineering Research Laboratory, Tsuchiura, Ibaraki, Japan), and K. Shiinoki (Hitachi, Ltd., Ebina

Work, Ebina, Kanagawa, Japan). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 139-146. 9 refs. (AIAA 81-0524)

The paper explains by both experiment and theoretical analysis that one nodal diameter mode of an impeller has a forwards and backwards whirling mode, and its frequencies are strongly affected by gyroscopic effect. The possibility of resonance, the resonant speed and whirling mode of an impeller due to gravity, unbalance and fluid force can be predicted by considering the relationship of natural frequencies between in a rotating and a fixed co-ordinate, and the anisotropy of a rotor. In addition, the present theory is contrasted with Southwell's method using centrifugal coefficient.

(Author)

**A81-29450 # Your next ground vibration test doesn't have to cost a million dollars.** D. Gimmestad (Boeing Co., Seattle, Wash.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 187-193. 8 refs. (AIAA 81-0529)

Recent improved methods offer substantial reductions in the cost of ground vibration testing along with significant improvements in accuracy. These improved methods, which involve the separation of the test into a measurement phase and an interpretation phase, are discussed from the point of view of a production flutter engineer. The improved effects of applying the improved methods are outlined, and suggestions on the successful utilization of these methods are presented. The application of the methods to the ground vibration testing of an A-10 is examined. B.J.

**A81-29453 # Application of a Fourier analyzer to the analysis of shimmy test data.** R. E. Shirley and M. Clark (Northrop Corp., Aircraft Div., Hawthorne, Calif.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 213-218. 5 refs. (AIAA 81-0533)

The use of a Fourier analyzer to extract frequency and damping information from F-5E nose gear data is described. The procedure provides a real time indication for predicting onset of nose gear shimmy by using a mode separation technique to isolate the modes in the random response. Frequency and damping extraction are therefore obtained without measuring the forcing function. The main excitation source is provided by runway roughness. Correlation of the results with analytical data from a five degree of freedom model provides a valuable basis for determining the relative importance of the parameters employed in the equations of motion. (Author)

**A81-29455 \* # Response of stiffened sandwich panels.** M. Slazak and R. Vaicaitis (Columbia University, New York, N.Y.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 237-245. 19 refs. Grant No. NsG-1450. (AIAA 81-0557)

An increasingly important part of the design of skin-stringer systems, such as those found in flight vehicles, is the ability to reduce surface vibration levels when they are subjected to the dynamic loads of jet, or propeller noise. One common method of reducing the response of these structures is by layered construction using viscoelastic materials. Thus analytical methods to describe such systems are essential. (Author)

**A81-29467 #** A study of the effect of store aerodynamics of wing/store flutter. C. D. Turner (Beech Aircraft Corp., Wichita, Kan.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2.

New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 343-351. 25 refs. (AIAA 81-0604)

Due to the high cost of doing flutter analysis for aircraft carrying large numbers and types of stores, it is not economically feasible to include store aerodynamics when there will be little change in the flutter results. But store aerodynamics should be included if it will change the results of the flutter analysis. This study represents the first systematic analytical study of the effect of store aerodynamics on wing/store flutter. A large number of wing/store single carriage configurations and parameters were included in the study: multivariate analysis techniques were used for the first time to analyze wing/store configurations, modal data, and flutter results. The results of the multivariate analysis indicate that it may not be possible to develop general guidelines, but it is possible to develop specific guidelines for use with a particular aircraft. (Author)

**A81-29469 #** Evaluation of methods for prediction and prevention of wing/store flutter. S. J. Pollock, W. A. Sotomayer, L. J. Huttshell, and D. E. Cooley (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, Ohio). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 362-372. 19 refs. (AIAA 81-0606)

Flight Dynamics Laboratory efforts in the areas of unsteady aerodynamics, flutter prediction, and active flutter suppression are discussed. These three areas are examined in relation to wing/store flutter, with specific examples presented from analyses and tests. Steady and unsteady pressure measurements were obtained in a wind tunnel at subsonic, transonic, and supersonic velocities on a fighter wing, tip mounted launcher and store, and underwing pylon and store. Store flutter calculations were carried out using both calculated and measured aerodynamics in order to determine the effect of store aerodynamics on the flutter characteristics. B.J.

**A81-29470 #** Aeroelastic tailoring of a composite winglet for KC-135. D. Gimmetstad (Boeing Military Airplane Co., Advanced Airplane Branch, Seattle, Wash.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 373-376. (AIAA 81-0607)

A composite winglet for KC-135 was aeroelastically tailored as the first step in the aeroelastic integration of a composite winglet into the airplane. The effects of aeroelasticity and winglets on wing structural design loads is reviewed. The winglet was sized in graphite/epoxy composite and in aluminum for a reference case. One aeroelastic tailoring exercise was carried out to minimize the elastic C(L-alpha) of the winglet and another to minimize the winglet cover panel weight. Substantially larger winglet aeroelastic losses result from the composite winglet than an aluminum winglet. It is shown that there is benefit in aeroelastically tailoring a composite winglet. (Author)

**A81-29471 \* #** Prediction of transonic flutter for a supercritical wing by modified strip analysis and comparison with experiment. E. C. Yates, Jr., E. C. Wynne, M. G. Farmer, and R. N. Desmarais (NASA, Langley Research Center, Loads and Aeroelasticity Div., Hampton, Va.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 377-405. 13 refs. (AIAA 81-0609)

The experiments of Farmer, Hanson, and Wynne (1976) showed that use of a supercritical airfoil can adversely affect wing flutter speeds in the transonic range. Inasmuch as adequate theories for three-dimensional unsteady transonic flow are not yet available, the modified strip analysis published by Yates in 1958 has been used to predict the transonic flutter boundary for the supercritical wing tested by Farmer, Hanson, and Wynne. The steady-state spanwise distributions of section lift-curve slope and aerodynamic center, required as input for the flutter calculations, were obtained from pressure distributions measured by Harris (1972). The calculated flutter boundary is in excellent agreement with experiment in the subsonic range. In the transonic range a 'transonic bucket' is calculated which closely resembles the experimental one with regard to both shape and depth, but it occurs at about 0.04 Mach number lower than the experimental one. (Author)

**A81-29472 #** The effect of the atmospheric turbulence on the rotor blade flap-leadlag motion stability in hovering. Y. Fujimori (National Aerospace Laboratory, Tokyo, Japan). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2.

New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 406-415. 7 refs. (AIAA 81-0610)

The general procedure has been proposed to study the stochastic stability characteristics of nonlinear differential equations with random parametric excitations. The method is based on the existence of the equilibrium of the deterministic system and the parametric excitations being infinitesimally small. The method has been applied to evaluate the motion stability of the coupled flap-leadlag motion in three dimensional atmospheric turbulence. The numerical examples of zero advance ratio flight show that the first and second moment stabilities possess almost identical boundaries and that the atmospheric turbulence has a favorable effect on the system stability. (Author)

**A81-29473 #** Feasibility of a rotor flight-dynamics model with first-order cyclic inflow and multiblade modes. G. H. Gaonkar, A. K. Mitra (Indian Institute of Science, Bangalore, India), and D. A. Peters (Washington University, St. Louis, Mo.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2.

New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 416-430. 12 refs. (AIAA 81-0611)

With the need of complementing the quasi-steady-inflow formulations at low advance ratios in combination with simplified rotor models, it is desirable to assess the feasibility of using only the first order forward and lateral cyclic components of multiblade modes and a time-delayed unsteady-momentum inflow. Such an approximation is appraised with reference to rigid flap-lag stability with dynamic inflow in forward flight. Three, four, and five bladed rotors are treated with and without periodic terms. For comparative purposes, that model is taken as exact which includes all the multiblade modes and a first harmonic distribution for inflow with three degrees of freedom. Numerical data are generated for trimmed and untrimmed conditions for a hierarchy of rotor-inflow models in which mean inflow perturbations, collective flap, collective lead-lag and second order multiblade cyclic components are neglected successively and collectively. (Author)

**A81-29474 \* #** In-flight structural dynamic characteristics of the XV-15 tilt rotor research aircraft. J. M. Bilger, R. L. Marr, and A. Zahedi (Bell Helicopter Textron, Fort Worth, Tex.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2.

New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 431-439. Contract No. NAS2-7800. (AIAA 81-0612)

The XV-15 tilt rotor research aircraft has recently completed

the contractor flight test program at the Bell Helicopter Textron Flight Research Center, Arlington, Texas. During these development and envelope expansion flights (60 flight hours, 140 flights), the aircraft has been tested up to a maximum true airspeed of 557 km/h (346 mph, 301 knts). Results of the structural characteristics obtained during this testing are presented. Included is a discussion concerning the rotor and airframe loads, natural frequency placements, airframe control system interaction, and wing-rotor-pylon aeroelastic stability. Measured data are compared with predicted values for many cases. (Author)

**A81-29475 #** **Determining the natural frequency of the combinative system of the helicopter rotor and elastic fuselage with mechanical impedance technique.** D.-M. Tang (Nanjing Aeronautical Institute, Nanjing, Communist China). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 440-443. (AIAA 81-0613)

This paper describes, from theoretical analysis and practical measurement of mechanical impedance, how to determine the natural frequency of the combinative system of the helicopter rotor and elastic fuselage, and the effect of dynamic characteristics of the rotor and fuselage on each other. The paper gives not only the resonance diagram of the combinative system, but also a practical example of dealing with the effect of boundary conditions in the design calculation of rotor dynamic characteristics. (Author)

**A81-29476 #** **Free-vibration analysis of rotating beams by a variable-order finite-element method.** D. H. Hodges and M. J. Rutkowski (U.S. Army, Aeromechanics Laboratory, Moffett Field, Calif.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 444-453. 23 refs. (AIAA 81-0614)

The free vibration of rotating beams is analyzed by means of a finite-element method of variable order. This method entails displacement functions that are a complete power series of a variable number of terms. The terms are arranged so that the generalized coordinates are composed of displacements and slopes at the element extremities and, additionally, displacements at certain points within the element. The displacement is assumed to be analytic within an element and thus can be approximated to any degree of accuracy desired by a complete power series. Numerical results are presented for uniform beams with zero and nonzero hub radii, for tapered beams, and for a nonuniform beam with discontinuities. Because the present method reduces to a conventional-beam finite-element method for a cubic displacement function, the results are compared with and found to be superior to the conventional results, in terms of accuracy for a given number of degrees of freedom. Indeed, essentially exact eigenvalues and eigenvectors are obtained with this technique, which is far more rapidly convergent than other approaches discussed in the literature. (Author)

**A81-29477 #** **Response characteristics of a linear rotorcraft vibration model.** D. L. Kunz (U.S. Army, Aeromechanics Laboratory, Moffett Field, Calif.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 454-462. 7 refs. (AIAA 81-0616)

A fully coupled vibration model, consisting of a rotor with only flapping degrees of freedom plus pylon and fuselage pitching motion, was used in a parametric study undertaken to investigate the response characteristics of a simplified helicopter. Among the parameters studied were uncoupled body frequency, blade stiffness, hinge offset, advance ratio, and mast height. Results from the

harmonic balance solution of the equations of the motion show how each of these quantities affects the response of the model. The results also indicate that there is a potential for reducing vibration response through the judicious definition of the design parameters. (Author)

**A81-29478 #** **Control settings for a trimmed, stalled rotor by an automatic feedback system.** D. A. Peters (Washington University, St. Louis, Mo.) and B. S. Kim. In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 463-470. 6 refs. Grant No. DAAG29-77-G-0103. (AIAA 81-0617)

An automatic feedback system, based on continuous monitoring of control loads, is used to find the control settings that are required to obtain a given flight condition of a helicopter rotor. Optimum values of gains and time constants are determined, the controller behavior is studied, and the limitations of the controller are examined for flap-pitch dynamics including a simple stall model. It is found that the present method shows good convergence, and it is superior to other trim techniques for systems with moderate damping or with many degrees of freedom. (Author)

**A81-29479 \* #** **Dynamic analysis of a free-tip rotor.** I. Chopra (NASA; Stanford Joint Institute of Aeronautics and Acoustics; Stanford University, Stanford, Calif.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 471-489. (AIAA 81-0618)

The flag-lag-torsion flutter of a constant-lift rotor (CLR) and a free-tip rotor (FTR) has been investigated in hovering flight. The CLR blade consists of a finite number of strips pivotally mounted on the spar; torsional stiffness of the strips is attained through the elastic axis offset from the aerodynamic center. It is shown that, with a suitable combination of lag damper and negative pitch-flap coupling, it is possible to design a CLR blade that is free of aeroelastic instability with suitable airfoil selection. The FTR blade, which consists of an inboard section similar to that of a conventional blade and a small outboard section freely pitching on its spar, is also free of aeroelastic instability. V.L.

**A81-29482 #** **Transient, nonlinear response analysis of soft bodied impact on flat plates including interactive load determination.** R. P. Nimmer (General Electric Co., Schenectady, N.Y.) and L. Boehman (Dayton, University, Dayton, Ohio). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 507-516. 20 refs. Contract No. F33615-77-C-5221. (AIAA 81-0621)

A nonlinear, finite element program has been adapted for the purpose of studying the response of fan blades to foreign object impact. Stress and added-stiffness effects of centrifugal loading are included. Analytical predictions of flat plate displacements under normal impact are compared with experimental results and good agreement is indicated. In addition, the program offers the option of interactive impact pressure calculation. In such a case, the impact pressures are calculated automatically, including the effects of both structural displacement and velocity. The program's ability to simultaneously consider load and response is illustrated for the case of an obliquely impacted flat plate. (Author)

**A81-29488 #** **Sonic fatigue design techniques for graphite-epoxy stiffened-skin panels.** I. Holehouse (Rohr Industries, Inc., Chula Vista, Calif.). In: Structures, Structural Dynamics and Materi-

als Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 574-579. 9 refs. USAF-sponsored research. (AIAA 81-0633)

A combined analytical and experimental program was conducted in order to develop a semi-empirical sonic fatigue design method for curved and flat graphite-epoxy skin-stringer panels. A range of multi-bay panels was subjected to high intensity noise environments in a progressive-wave tube. Shaker tests were also performed in order to provide additional random fatigue data. Finite-element analyses were carried out on the test panel designs, generating static strains and frequencies. Multiple stepwise regression analysis was used to develop the sonic fatigue design method. Design equations and a nomograph are presented. Comparisons of sonic fatigue resistance between graphite and aluminum panels were also carried out. The design method developed is presented as a self-contained section and is suitable for practical design use. (Author)

**A81-29489 #** **Aeroservoelasticity in the time domain.** M. A. Cutchins (Auburn University, Auburn, Ala.), J. W. Purvis (Sandia Laboratories, Albuquerque, N. Mex.), and R. W. Bunton (USAF, Eglin AFB, Fla.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 580-590. 48 refs. Contract No. F08635-78-C-0027. (AIAA 81-0635)

A nonlinear technique is presented for stability assessment of high performance aircraft in the time domain. The proposed approach involves the use of an advanced simulation language with mnemonic features and allows simultaneous solution of large systems of aerodynamic, inertial, elastic, and servo-control equations. Reasonable agreement in the time domain with an in-flight test case, missiles-on and missiles-off, has been obtained using aeroservoelastic simulations of (1) roll only, (2) roll only with elastic effects, and (3) six degrees of freedom only. V.L.

**A81-29491 #** **Active control of forward swept wings with divergence and flutter aeroelastic instabilities.** K. E. Griffin (U.S. Air Force Academy, Colorado Springs, Colo.) and F. E. Eastep (Dayton, University, Dayton, Ohio). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 602-610. 5 refs. (AIAA 81-0637)

A study is made of simple active control laws to suppress aeroelastic flutter and divergence on forward swept advanced composite wings. Two selected wing designs are used as examples where leading and trailing edge flaps are used as control devices. These flaps are actuated using simple feedback signals from acceleration, velocity, and displacement sensors. The analysis method uses root locus plots of the characteristic root from the transformed equations of motion to determine the aeroelastic stability of each feedback controlled configuration. The transformed aerodynamic forces are expressed as Padé Approximates obtained from a least-squares fitting scheme of sinusoidal generalized aerodynamic forces. The leading edge flap and elastic displacement sensing seemed to be the best technique for controlling divergence speed of forward swept wings. In the selected examples, an increase of divergence speed of approximately 25 percent is demonstrated. The flutter speed is increased by 30 percent with a trailing edge flap and acceleration sensing. (Author)

**A81-29493 \* #** **Wind-tunnel evaluation of NASA developed control laws for flutter suppression on a DC-10 derivative wing.** I. Abel and J. R. Newsom (NASA, Langley Research Center, Loads and Aeroelasticity Div., Hampton, Va.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga.,

April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 621-632. 5 refs. (AIAA 81-0639)

Two flutter suppression control laws have been synthesized, implemented, and tested on a low-speed aeroelastic wing model of a DC-10 derivative. The methodology used to design the control laws is described. Both control laws demonstrated increases in flutter speed in excess of 25 percent above the passive wing flutter speed. The effect of variations in gain and phase on the closed-loop performance was measured and is compared with analytical predictions. In general, the analytical results are in good agreement with experimental data. (Author)

**A81-29494 \* #** **Qualitative comparison of calculated turbulence responses with wind-tunnel measurements for a DC-10 derivative wing with an active control system.** B. Perry, III (NASA, Langley Research Center, Loads and Aeroelasticity Div., Hampton, Va.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 633-643. (AIAA 81-0567)

This paper presents comparisons of analytically-predicted and experimental turbulence responses of a wind-tunnel model of a DC-10 derivative wing equipped with an active control system. The active control system was designed for the purpose of flutter suppression, but it had the additional benefit of alleviating gust loads (wing bending moment) by about 25 percent. Comparisons of various wing responses are presented for variations in active-control-system parameters and tunnel speed. The analytical turbulence responses were obtained using DYLOFLEX, a computer program for dynamic loads analyses of flexible airplanes with active controls. In general, the analytical predictions agreed reasonably well with the experimental data. (Author)

**A81-29495 \* #** **Comparison of analysis and flight test data for a drone aircraft with active flutter suppression.** J. R. Newsom (NASA, Langley Research Center, Loads and Aeroelasticity Div., Hampton, Va.) and A. S. Pototzky (Kentrion International, Inc., Hampton, Va.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 644-653. 16 refs. (AIAA 81-0640)

This paper presents a comparison of analysis and flight test data for a drone aircraft equipped with an active flutter suppression system. Emphasis is placed on the comparison of modal dampings and frequencies as a function of Mach number. Results are presented for both symmetric and antisymmetric motion with flutter suppression off. Only symmetric results are presented for flutter suppression on. Frequency response functions of the vehicle are presented from both flight test data and analysis. The analysis correlation is improved by using an empirical aerodynamic correction factor which is proportional to the ratio of experimental to analytical steady-state lift curve slope. In addition to presenting the mathematical models and a brief description of existing analytical techniques, an alternative analytical technique for obtaining closed-loop results is presented. (Author)

**A81-29496 \* #** **Linear/nonlinear behavior in unsteady transonic aerodynamics.** E. H. Dowell, M. H. Williams (Princeton University, Princeton, N.J.), and S. R. Bland (NASA, Langley Research Center, Unsteady Aerodynamics Branch, Hampton, Va.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 654-670. 15 refs. (AIAA 81-0643)

The accurate calculation of the aerodynamic forces in unsteady transonic flow requires the solution of the nonlinear flow equations.



The aeroelastician, on the other hand, seeks to treat his problems (flutter, for example) by means of linear equations whenever possible. He may do this, even when the underlying flow is nonlinear, if the perturbation forces are linear over some (perhaps small) range of unsteady amplitude of motion. This paper assesses the range of parameters over which linear behavior occurs. In particular calculations are made for an NACA 64A006 airfoil oscillating in pitch over a range of amplitudes, frequencies, and Mach numbers. The primary aerodynamic method used is the well known LTRAN2 code of Ballhaus and Goorjian that provides a finite-difference solution to the low frequency, small disturbance, two-dimensional potential flow equation. Comparisons are made with linear subsonic theory, local linearization, and, for steady flow, with the full potential equation code of Bauer, Garabedian, and Korn. (Author)

**A81-29497 #** On some methods of supersonic unsteady lifting surface analysis. P. F. Jordan. In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 671-676. 5 refs. Contract No. F33615-79-C-3030. (AIAA 81-0644)

The paper examines the mathematical bases of several methods of supersonic unsteady lifting surface analysis including Mach box method, doublet-lattice method, and the potential gradient method of Jones and Appa (1977). It is shown that the Mach box method can be improved by shifting the receiving point back to the 60.581% chord position. The doublet-lattice method may be less suitable for supersonic flow than it is for subsonic flow. For the potential gradient method, the rate of convergence of the first four terms has been demonstrated and supplementary formulas have been presented. V.L.

**A81-29498 #** Unsteady aerodynamic propulsion. J. K. Nathman (Stanford University, Stanford, Calif.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 677-685. 22 refs. USAF-sponsored research. (AIAA 81-0645)

An investigation into the thrust of oscillating wings has been completed. Analytical and experimental calculations of the forces on two-dimensional airfoils are presented. It is shown that a slight amount of oscillatory camber has beneficial effects in increasing thrust and reducing the likelihood of stall. For 2-D wings there is a simple approximate relationship between the optimal thrust and efficiency which other researchers have shown applies in 3-D. To compare theory with experiment it was necessary to derive the effect of the wind-tunnel walls which is shown to be quite significant in the case of the thrust force for small wind-tunnel height to wing chord ratios. (Author)

**A81-29499 #** An improved potential gradient method to calculate airloads on oscillating supersonic interfering surfaces. M. H. L. Houtjet (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 686-698. 24 refs. Research supported by the Royal Netherlands Air Force. (AIAA 81-0646)

A description is given of a computationally improved potential gradient method to calculate unsteady aerodynamic derivatives in supersonic flow. Results are presented and comparisons are made with results of existing methods and with experimental data for a fighter-type wing. (Author)

**A81-29500 \* #** On the convergence of unsteady generalized aerodynamic forces. W. S. Rowe (Boeing Commercial Airplane Co.,

Flutter Research Group, Renton, Wash.) and H. J. Cunningham (NASA, Langley Research Center, Unsteady Aerodynamics Branch, Hampton, Va.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 699-708. 10 refs. (AIAA 81-0647)

Variations in generalized forces calculated by different computer programs are traced to improper mathematical modeling techniques. Comparisons of generalized forces calculated by three theoretical methods are presented to illustrate difficulties involved in obtaining prediction convergence for increasing wave number. Use of a sufficiently dense chordwise paneling arrangement, in finite panel methods, results in predictions that are essentially identical to predictions of converged solutions. Procedural modifications are suggested for application in finite panel methods to increase prediction accuracy and reduce computer usage costs. (Author)

**A81-29501 #** Aerodynamic modeling of an oscillating wing with external stores. W. A. Sotomayer (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, Ohio), A. R. Dusto, M. A. Epton, and F. T. Johnson (Boeing Aerospace Co., Seattle, Wash.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 709-729. 21 refs. (AIAA 81-0648)

An analysis of the steady and unsteady aerodynamic forces acting on a fighter aircraft wing with stores has been done. Computations were performed with paneling methods capable of representing arbitrary aircraft configurations in subsonic and supersonic flow. Interference effects from a tipstore and an underwing pylon store in varying stages of completion were also analyzed. Detailed comparisons between experimental data and numerical computations are also made. (Author)

**A81-29502 #** A new frequency parameter for unsteady aerodynamics. S. R. Anthony and M. R. Myers (Lockheed-Georgia Co., Marietta, Ga.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 730-732. (AIAA 81-0649)

A new frequency parameter that minimizes the number of points required to represent unsteady aerodynamics has been developed. The parameter expands the low range of the reduced frequencies where the aerodynamics vary rapidly and compresses the moderate to high frequency range into a finite domain. Four examples showing the general applicability of the parameter are presented. (Author)

**A81-29503 \* #** Transonic flutter and gust-response tests and analyses of a wind-tunnel model of a torsion-free-wing fighter airplane. C. L. Ruhl (NASA, Langley Research Center, Loads and Aeroelasticity Div., Hampton, Va.) and A. C. Murphy (General Dynamics Corp., Structures and Design Dept., Fort Worth, Tex.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 733-747. (AIAA 81-0650)

The paper reports the results of analytical and exploratory wind-tunnel studies of the transonic flutter and gust response characteristics of a 1/5.5-size complete-airplane version of a torsion-free-wing (TFW) fighter aircraft. The critical flutter mode for the TFW-free configuration was found to occur at  $M = 0.95$  and had the rigid-TFW pitch mode as its apparent aerodynamic driver. However, the minimum dynamic flutter for the TFW-free case was only about 20% lower than for the TFW-locked; therefore the present TFW is a

viable design concept with respect to flutter. The present TFW was not effective as a gust alleviator. V.L.

**A81-29504 # A wind-tunnel study of the flutter characteristics of a supercritical wing.** R. Houwink, A. N. Kraan, and R. J. Zwaan (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 748-754. 5 refs. Research supported by the Nederlands Instituut voor Vliegtuigontwikkeling en Ruimtevaart.

A wind-tunnel flutter test on a supercritical wing model is described. Objectives of the test were to investigate the transonic dip and to enable comparisons with calculated flutter characteristics in which a quasi-3-D transonic theory was used. The beginning of a transonic dip was measured and a satisfactory agreement with theory could be found. An additional flutter instability in the bottom of the transonic dip could be correlated with the loose of transition strip effectivity at low Reynolds numbers. (Author)

**A81-29506 \* # Transonic flutter study of a wind-tunnel model of an arrow-wing supersonic transport.** C. L. Ruhlin (NASA, Langley Research Center, Loads and Aeroelasticity Div., Hampton, Va.) and C. R. Pratt-Barlow (Boeing Commercial Airplane Co., Preliminary Design Group, Seattle, Wash.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 764-777. 12 refs. (AIAA 81-0654)

A 1/20-size, low-speed flutter model of the SCAT-15F complete airplane was tested in a wind-tunnel on cables to simulate a near free-flying condition. Only the model wing and fuselage were flexible. Flutter boundaries were measured for a nominal configuration and a configuration with wing fins removed at Mach numbers M from 0.76 to 1.2. For both configurations, the transonic dip in the wing flutter dynamic pressure q boundary was relatively small and the minimum flutter q occurred near M = 0.92. Removing the wing fins increased the flutter q about 14 percent and changed the flutter mode from symmetric to antisymmetric. Vibration and flutter analyses were made using a finite-element structural representation and subsonic kernel-function aerodynamics. For the nominal configuration, the analysis (using calculated modal data) predicted the experimental flutter q levels within 10 percent but did not predict the correct flutter mode at the higher M. For the configuration without wing fins, the analysis predicted 16 to 36 percent unconservative (higher than experimental) flutter q levels and showed extreme sensitivity to mass shapes. (Author)

**A81-29507 \* # Flight test results of an active flutter suppression system installed on a remotely piloted research vehicle.** J. W. Edwards (NASA, Langley Research Center, Hampton, Va.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 778-789. 11 refs. (AIAA 81-0655)

Flight flutter test results of the first aeroelastic research wing of NASA's Drones for Aerodynamic and Structural Testing (DAST) program are presented. The implementation of the flutter suppression system and the flight test operation are described. The conduct of the flutter testing and the near-real time damping estimation algorithm are also described in detail. Flight data was obtained at Mach numbers up to 0.91 and was of high quality. Response to fast frequency sweep excitation provided reliable damping estimates and the open-loop flutter boundary was well defined. Evidence of angle-of-attack effects upon damping at high transonic Mach numbers is also presented. While the flutter suppression system provided

augmented damping at speeds below the flutter boundary, an error in the implementation of the system gain caused the system to be less stable than predicted and the vehicle encountered system-on flutter on the third flight. (Author)

**A81-29508 # Subcritical flutter and oscillatory pressure testing of a full-scale 727 inboard aileron in a low-speed wind-tunnel.** K. S. Nagaraja, G. C. Lakin, and J. B. Bartley (Boeing Commercial Airplane Co., Seattle, Wash.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 790-796. (AIAA 81-0656)

This paper presents the subcritical flutter characteristics of a rigid full-scale 727 wing segment with inboard aileron-tab that was tested in a low-speed wind-tunnel. The airplane lateral-control system was simulated, and testing was performed with and without the internal-pressure balance panel. Subcritical damping characteristics of the binary flutter mode were measured for three cases of tab mass balance and compared with analyses. In addition, oscillatory pressures in the region of the control surface and aileron hinge moments were measured for a wide range of reduced frequencies. The flutter test confirmed the stability of a lightly damped aileron and tab flutter mode that had been identified analytically using doublet-lattice unsteady aerodynamics. The aileron and tab flutter mode was observed to reach a limit cycle amplitude in the wind-tunnel. Correlation of test results with analysis was found to be dependent on the scaling of the aileron and tab aerodynamic derivatives. A qualitative agreement was found with the calculated oscillatory pressures and hinge moments. (Author)

**A81-29511 \* # Application of a flight test and data analysis technique to flutter of a drone aircraft.** R. M. Bennett and I. Abel (NASA, Langley Research Center, Loads and Aeroelasticity Div., Hampton, Va.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 811-820. 12 refs. (AIAA 81-0652)

Modal identification results are presented that were obtained from recent flight flutter tests of a drone vehicle with a research wing equipped with an active flutter suppression system (FSS). Frequency and damping of several modes are determined by a time domain modal analysis of the impulse response function obtained by Fourier transformations of data from fast swept sine wave excitation by the FSS control surfaces on the wing. Flutter points are determined for two different altitudes with the FSS off. Data are given for near the flutter boundary with the FSS on. (Author)

**A81-29512 \* # A hybrid state vector approach to aeroelastic analysis with application to composite lifting surfaces.** L. L. Lehman (Stanford University, Stanford, Calif.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 821-831. 23 refs. Grants No. AF-AFOSR-77-3263; No. NGL-05-020-243. (AIAA 81-0626)

A computational technique has been developed for performing preliminary design aeroelastic analyses of large aspect ratio lifting surfaces. This technique, applicable to both fixed and rotating wing configurations, is based upon a formulation of the structural equilibrium equations in terms of a hybrid state vector containing generalized force and displacement variables. An integrating matrix is employed to solve these equations for divergence and flutter eigenvalues and steady aeroelastic deformation. Results are presented for simple examples which verify the technique and demonstrate how it can be applied to analyze lifting surfaces, including those constructed from composite materials. (Author)

**A81-29513 \* #** Dynamic stability of a rotor blade using finite element analysis. N. T. Sivaneri and I. Chopra (NASA; Stanford Joint Institute for Aeronautics and Acoustics; Stanford University, Stanford, Calif.). In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 832-843. 16 refs. Grant No. NCC2-13. (AIAA 81-0615)

The aeroelastic stability of flap bending, lead-lag bending, and torsion of a helicopter rotor blade in hover is examined using a finite element formulation based on the principle of virtual work. Quasi-steady two-dimensional airfoil theory is used to obtain the aerodynamic loads. The rotor blade is discretized into beam elements, each with ten modal degrees of freedom. The resulting nonlinear equations of motion are solved for steady-state blade deflections through an iterative procedure. The flutter solution is calculated assuming blade motion to be a small perturbation about the steady solution. The normal mode method based on the coupled rotating natural modes about the steady deflections is used to reduce the number of equations in the flutter eigenanalysis. Results are presented for hingeless and articulated rotor blade configurations.

(Author)

**A81-29678** The anatomy of the aeroplane. D. Stinton. London, Granada Publishing, Ltd., 1980. 342 p. 18 refs. \$23.50.

Topics discussed include requirements and specifications for aircraft design, the choice of powerplants, the generation of aerodynamic forces and variation of lift and drag, and the aerodynamic balancing of control forces. Consideration is also given to the fundamental differences between landplanes and seaplanes, the design of aircraft structures, and the distribution of weights and its effect on center of gravity and control. A series of appendices covers the design histories of light and utility aircraft, subsonic and supersonic transports, and strike, reconnaissance and counter-insurgency military aircraft. The range of aircraft designs covered is largely British, and may be dated from 1950 to 1970. O.C.

**A81-29680** Gas turbine engineering: Applications, cycles and characteristics. R. T. C. Harman (Canterbury, University, Christchurch, New Zealand). New York, Halsted Press, 1981. 288 p. 145 refs. \$29.95.

Aircraft engine experience is used to discuss the design, operation, performance characteristics, and current problems of radial and axial compressors and turbines, as well as combustion. The complete engine is discussed in terms of matching the compressor to the turbine, its operating characteristics and the effects of altitude, fuel systems and control, noise, structural loads, vibration, bearings, lubrication, testing, and safety. Turbochargers are also covered briefly. In addition to transport and power generation applications, various applications in processing industries and chemical engineering are discussed. V.L.

**A81-29774** An operational tilt-rotor this decade. M. Lambert. *Interavia*, vol. 36, Apr. 1981, p. 302, 303.

The development status of the XV-15 tilt-rotor VTOL aircraft is reviewed, and the operational characteristics and cost effectiveness of proposed civilian and military derivatives are projected. Comparisons with state-of-the-art helicopter designs show the tilt-rotor aircraft to be inherently more expensive, but able to compensate for higher procurement and operating costs with a high-speed, high-altitude cruise capability crucial to military applications. Among the missions contemplated for Army, Navy, and Marine Corps versions of the XV-15 are troop transport, ASW, target designation for guided missiles, search and rescue, mine-sweeping, and antiarmor gun and missile platform. It is concluded to be on the strength of such high-performance versatility that the role of the helicopter can be assumed and improved by future tilt-rotor aircraft. O.C.

**A81-29775** Electronic engine control for commercial aircraft. G. Dienger and B. Bialojan (Deutsche Lufthansa AG, Hamburg, West Germany). *Interavia*, vol. 36, Apr. 1981, p. 313-317.

The development of turbofan airliner engine control systems, from purely hydromechanical, through electronically supervised, to full-authority digital stages, is reviewed. Attention is given to the impact of the progressive incorporation of electronics on reduction of specific fuel consumption, maintenance and modification costs, and flight deck operations complexity, and on improvements in thrust-to-weight-ratio and reliability. O.C.

**A81-29850** Turbine blade construction of multistage axial-flow compressors (Beschaulungsauslegung vielstufiger Axialverdichter). K. Grahl. *VDI-Zeitschriften Fortschritt-Berichte, Reihe 7 - Strömungstechnik*, no. 57, Sept. 1980, p. I, III, 1-39. 105 refs. In German.

A survey is given of techniques and problems of the turbine blade construction of multistage axial-flow compressors. The influence of a number of parameters on the choice of an optimum cascade is examined. The design starting point is determined from the choice of the profile type, the choice of cascade boundaries, and other influence parameters. Additional calculations are given such as the consideration of the side wall boundary layer, the determination of the profile characteristics and the conversion of the profile data from a flow-oriented diagonal profile to an axis-parallel blade profile. The application of the method is demonstrated using the example of the first turbine wheel of a multistage compressor. D.K.

**A81-29860** On the theory of a wing with small aspect ratio in a hypersonic flow. V. N. Golubkin. (*Akademiia Nauk SSSR, Mekhanika Zhidkosti i Gaza*, July-Aug. 1980, p. 112-117.) *Fluid Dynamics*, vol. 15, no. 4, Jan. 1981, p. 564-569. 11 refs. Translation.

In the present paper, the hypersonic flow past three-dimensional small-aspect-ratio wings of a configuration resembling a delta wing is analyzed. The results make it possible to assess the influence of the leading-edge planform and wing camber on the flow pattern at the windward side of the wing and the corresponding gasdynamic functions. V.P.

**A81-29864** Laminar boundary layer on an oscillating wedge. G. N. Stepanov. (*Akademiia Nauk SSSR, Mekhanika Zhidkosti i Gaza*, July-Aug. 1980, p. 146-151.) *Fluid Dynamics*, vol. 15, no. 4, Jan. 1981, p. 594-599. Translation.

The analysis deals with the laminar boundary layer on a sharp wedge which performs slow harmonic fluctuations in a compressible ideal gas flow. A solution in linear approximation is obtained under the assumption that the perturbations produced by the wedge are small and that the boundary layer thickness is small in comparison to that of the perturbed region. V.P.

**A81-29866** Experimental investigation into the reaction of a boundary layer to external periodic disturbances. A. V. Dovgal', V. V. Kozlov, and V. Ia. Levchenko. (*Akademiia Nauk SSSR, Mekhanika Zhidkosti i Gaza*, July-Aug. 1980, p. 155-159.) *Fluid Dynamics*, vol. 15, no. 4, Jan. 1981, p. 602-606. 10 refs. Translation.

The paper deals with a low turbulence wind tunnel investigation of the response of a boundary layer on a plate to a concentrated external effect. The latter was simulated by generating a disturbance, localized above the plate, in the flow. Measurements revealed the onset of Tollmien-Schlichting waves in the boundary layer, which are regarded as the initial linear stage of laminar-turbulent transition. This result indicates that the experimental technique employed is an effective means of generating natural oscillations in boundary layers. V.P.

**A81-29867** Roll length of an annular underexpanded jet formed by a sonic nozzle with cylindrical rod on its axis. Iu. Ia. Borisov and S. L. Podolskii. (*Akademiia Nauk SSSR, Mekhanika Zhidkosti i Gaza*, July-Aug. 1980, p. 167-171.) *Fluid Dynamics*, vol. 15, no. 4, Jan. 1981, p. 615-619. 9 refs. Translation.

Modern sound emitters generating sonic and ultrasonic high-intensity oscillations in gases operate by the principle of the Hartmann generator. They employ annular jets that are formed in conical nozzles with a cylindrical inner body. The effectiveness of such emitters has been found to depend to a great degree on the variation of the jet structure along a solid surface. In the present experiments, schlieren photography is used to study the length of the first barrel distortion on an annular jet at elevated pressure gradients, as well as the influence of the nozzle cone angle. The results are illustrated and analyzed. V.P.

**A81-29926 # The evaluation of fuel property effects on Air Force gas turbine engines - Program Genesis.** T. A. Jackson (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-1.* 9 p. 7 refs. Members, \$2.00; nonmembers, \$4.00.

The Air Force has conducted a series of investigations to quantify the effects of certain fuel properties on the operability and durability of its aircraft gas turbine engines. Initially these efforts were conducted on a small number of engines intended to be representative of the majority of gas turbine engines in the Air Force inventory. The testing was conducted exclusively in rigs representing the combustor and fuel nozzle components of these engines of interest. Test fuels for these programs were primarily blends of hydrocarbons. These test fuels exhibited significant variations in several major fuel properties. Based on results of these evaluations a second generation of test activity in fuel effects area was formulated. Engine system selection was broadened to include more considerations. Test fuels were reduced in number and priorities for modification of certain fuel properties were adjusted. This paper presents dominant test results of early fuel effects programs and supplemental background which dictated the structure of the second, more comprehensive program. (Author)

**A81-29927 # Impacts of broadened-specification fuels on aircraft turbine engine combustors.** D. W. Bahr (General Electric Co., Aircraft Engine Group, Cincinnati, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-2.* 9 p. 10 refs. Members, \$2.00; nonmembers, \$4.00.

Key results of several experimental investigations aimed at quantifying the impact of fuel property changes on aircraft turbine engine performance are presented. Fuels with hydrogen content, fluidity/volatility characteristics and thermal stability ratings lower than the norm were used in both component and full engine tests of CF6, F101, and J79 combustors. Test results show that decreased combustor life and ground starting/altitude relight capabilities and increased fuel injector gumming/coking tendencies may be expected to follow from fuel characteristics changes. Combustor design features needed to circumvent these problems are discussed. O.C.

**A81-29928 # Stalling pressure rise capability of axial flow compressor stages.** C. C. Koch (General Electric Co., Aircraft Engine Group, Evendale, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-3.* 12 p. 20 refs. Members, \$2.00; nonmembers, \$4.00.

A simplified stage average pitchline approach is described for estimating the maximum pressure rise potential of axial flow compressor stages, which can be used in preliminary design prior to the establishment of blading geometry and fluid parameters. Semi-empirical correlations of low speed experimental data presented relate the stalling static pressure rise coefficient of a compressor stage to cascade passage geometry, tip clearance, bladerow axial spacing, and Reynolds number. O.C.

**A81-29930 # Finite element methods for transonic blade-to-blade calculation in turbomachines.** H. Deconinck (Instituut tot Aanmoediging van het Wetenschappelijk Onderzoek in Nijverheid en Landbouw; Brussel, Vrije Universiteit, Brussels, Belgium) and Ch.

Hirsch (Brussel, Vrije Universiteit, Brussels, Belgium). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-5.* 13 p. 38 refs. Members, \$2.00; nonmembers, \$4.00.

The transonic cascade flow is calculated with an efficient and flexible Galerkin finite element method applied to the full potential equation in artificial compressibility form. Some of the typical advantages of finite element techniques are demonstrated such as the use of higher order discretization with biquadratic elements besides the classical bilinear second order accurate element, automatic treatment of the body-fitted mesh due to the locally defined isoparametric mapping, and easy and exact introduction of arbitrary Neumann boundary conditions along curvilinear boundaries. On the other hand, the conceptual simplicity and efficiency of the finite difference methods based on the same equation and developed for external flows are fully maintained by the use of linear relaxation or approximate factorization for the iterative solution algorithm, eventually combined with a multigrid approach. The important problem of obtaining a well-constructed mesh is solved satisfactorily by automatic grid generation based on the solution of two elliptic partial differential equations. Calculations are presented and compared with experimental data for both compressor and turbine cascade flows containing shocks. (Author)

**A81-29931 # Development of a large-scale wind tunnel for the simulation of turbomachinery airfoil boundary layers.** M. F. Blair, D. A. Bailey, and R. H. Schlinker (United Technologies Research Center, East Hartford, Conn.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-6.* 10 p. 21 refs. Members, \$2.00; nonmembers, \$4.00. Research supported by the United Technologies Corp.; Contract No. F49620-78-G-0064.

The design and performance testing of a wind tunnel for the generation of large-scale, two-dimensional boundary layers on a heated flat surface, having the Reynolds numbers, pressure gradients, and free-stream turbulence levels typical of turbomachinery airfoils, are described. Test boundary-layer profile and convective heat transfer data were found to be in agreement with classic correlations, and the test section free-stream turbulence was shown to be both homogeneous and nearly isotropic. Applications of the facility will include studies of the heat transfer and aerodynamics for conditions typical of those existing on gas turbine blades. O.C.

**A81-29932 # The effect of impeller tip design on the performance of a mixed flow turbocharger compressor.** A. Whitfield and D. V. Roberts (Bath, University, Bath, Somerset, England). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-7.* 7 p. 11 refs. Members, \$2.00; nonmembers, \$4.00.

Performance test results are presented for three mixed flow impellers whose discharge blade tip is designed to reduce enthalpy gradients at the vaneless diffuser inlet. It is demonstrated that overall flow stability between low and high rotational speeds is improved by using a mixed flow impeller whose vane tips are cut off horizontally. Centrifugal compressor impellers of this design are useful in turbocharger applications. O.C.

**A81-29937 # Efficiency prediction for axial-flow turbines operating with nonconventional fluids.** E. Macchi and A. Pedichizzi (Milano, Politecnico, Milan, Italy). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-15.* 7 p. 11 refs. Members, \$2.00; nonmembers, \$4.00.

The need for a simple and reliable method for predicting the efficiency of a turbine stage without carrying out a detailed aerodynamic design is enhanced. The results of an optimization study carried out on a large number of turbine stages are presented. The turbine stage efficiency is found to be a function of three main parameters: the expansion ratio, defined as the specific volume variation across the turbine in an isentropic process; a dimensional parameter, which accounts for actual turbine dimensions, and the

specific speed. The presented method is believed to be useful mainly for nonconventional turbine stages, the efficiency of which cannot be anticipated on previous machines experience. (Author)

**A81-29938 # Further studies of the influence of thermal effects on the predicted acceleration of gas turbines.** N. R. L. MacCallum (Glasgow, University, Glasgow, Scotland). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-21.* 8 p. 8 refs. Members, \$2.00; nonmembers, \$4.00.

A previous study has investigated the effect of changes in compressor characteristics, due to transient heat transfers, on the predicted accelerations of a single-spool aero gas turbine of pressure ratio 9.5. In the present paper the analysis is extended to a two-spool bypass engine of pressure ratio 21. The increases in the predicted acceleration times of this engine, due to the inclusion of heat absorption and compressor characteristic change, are more marked than with the lower pressure ratio engine, depending on the fuel schedule used. The effects of changes in component efficiencies on predicted acceleration have also been studied. Again, the higher pressure ratio engine shows the greater influence. Compared with thermal absorptions, it is likely that component efficiency changes have as much, if not more effect on predicted accelerations.

(Author)

**A81-29939 # The development of a substitute bird model.** J. S. Wilbeck and J. L. Rand (Southwest Research Institute, San Antonio, Tex.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-23.* 6 p. 11 refs. Members, \$2.00; nonmembers, \$4.00. Contract No. F33615-73-C-5027. AF Project 7351; AF Task 735106.

A comprehensive program was conducted to develop a model synthetic bird for use in engine blade impact testing. A hydrodynamic theory of the impact event was used to aid in determining the bird properties which had to be duplicated in the model. Of the two candidate models studied extensively, it was determined that a projectile fabricated from commercial gelatin impregnated with phenolic microballoons most nearly duplicated the impact loading history of real birds.

(Author)

**A81-29940 \* # Superhybrid composite blade impact studies.** C. C. Chamis, R. F. Lark, and J. H. Sinclair (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-24.* 8 p. 5 refs. Members, \$2.00; nonmembers, \$4.00.

An investigation was conducted to determine the feasibility of superhybrid composite blades for meeting the mechanical design and impact resistance requirements of large fan blades for aircraft turbine engine applications. Two design concepts were evaluated: (1) leading edge spar (TiCom) and (2) center spar (TiCore), both with superhybrid composite shells. The investigation was both analytical and experimental. The results obtained show promise that superhybrid composites can be used to make light-weight, high-quality, large fan blades with good structural integrity. The blades tested successfully demonstrated their ability to meet steady-state operating conditions, overspeed, and small bird impact requirements. (Author)

**A81-29941 # Pattern factor improvement in the F-100 primary combustion system.** G. B. Cox, Jr., A. R. Tiller, J. J. LeTourneau (United Technologies Corp., Pratt and Whitney Aircraft Group, West Palm Beach, Fla.), and J. S. Ogg (USAF, Wright-Patterson AFB, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-25.* 10 p. 6 refs. Members, \$2.00; nonmembers, \$4.00.

The test methodology and findings of the F-100 military turbofan combustor development program, aimed at improvement of the annular combustor's exit temperature pattern, are described. The combustor liner modifications tested, the instrumentation of rig and

full engine tests, the statistical analysis methods used to characterize the data derived, and the water tunnel flow pattern tests used to study turbulence are discussed in detail. O.C.

**A81-29942 # The influence of premixed combustion flame stabilizer geometry on flame stability and emissions.** N. A. Al Dabbagh and G. E. Andrews (Leeds University, Leeds, England). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-26.* 10 p. 33 refs. Members, \$2.00; nonmembers, \$4.00. Research supported by the Science Research Council.

Premixed combustion systems for gas turbines offer the possibility of low-pollution, high-combustion efficiency and good temperature distribution. They form a basis by which other well-mixed combustion systems may be assessed. The ultimate objective of this work is the development of nonpremixed rapid mixing combustion systems. Different geometries of baffle flame stabilizers are tested to study the influence of recirculation zone size and number of recirculation zones on flame stability, combustion efficiency and NO(x). The results show that the flame stabilizer geometry has a major influence on combustion efficiency and flame stability but a lesser influence on NO(x). Optimum equivalence ratios are identified for good combustion efficiency and low NO(x) at simulated low and high-power engine conditions.

(Author)

**A81-29943 # An exploratory study of soot sample integrity and probe perturbation in a swirl-stabilized combustor.** R. L. Hack, G. S. Samuelsen (California, University, Irvine, Calif.), C. C. Poon, and W. D. Bachalo (Spectron Development Laboratories, Costa Mesa, Calif.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-27.* 13 p. 11 refs. Members, \$2.00; nonmembers, \$4.00. Contract No. F08635-79-C-0158.

In-flame measurements of soot particulate using conventional extractive and nonintrusive optical probes are compared for a swirl-stabilized combustor. Except for large (approximately 5-microns) particulate present in the extracted samples, the soot particle size compares favorably with optically measured values, and the soot particle morphology reflects that formed in gas turbine combustors. Two nonflame sources for the large particulate are suggested by the optical data: particles formed or elongated during transport subsequent to extraction, and particles attrited from upstream carbon deposits on a solid surface. The extractive probe produces a change in the local particle number density which varies from little change to a 70-fold suppression in reacting flow and a 200-fold increase in cold seeded flow depending on the location within the combustor of the optical sampling volume, the location of the extractive probe relative to the optical sampling volume, and the combustor operating conditions.

(Author)

**A81-29944 # Preliminary study on reheat combustor for advanced gas turbine.** K. Mori, J. Kitajima, T. Kimura (Kawasaki Heavy Industries, Ltd., Technical Institute, Akashi, Japan), and S. Miki (Kawasaki Heavy Industries, Ltd., Development Dept., Tokyo, Japan). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-29.* 8 p. 13 refs. Members, \$2.00; nonmembers, \$4.00. Research sponsored by the Agency of Industrial Science and Technology and Engineering Research Association for Advanced Gas Turbines.

Following feasibility study indications of high temperature reheat gas turbine/steam turbine combined cycle thermal efficiencies as high as 50%, tests were conducted on a reheat combustor which will operate at 973 K with heavily vitiated (12.4% O<sub>2</sub>) inlet-air conditions. The design considerations and results of near-atmospheric pressure tests for the reheat combustor are detailed, and the effects of air vitiation on flammability limits, combustion efficiency, nitrogen oxide emissions, and gas turbine combustor wall temperatures are discussed. O.C.

## A81-29946

**A81-29946 # MS9001E - A new 100 MW gas turbine.** J. C. Rucigay and A. J. Orsino (General Electric Co., Gas Turbine Div., Schenectady, N.Y.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-31.* 8 p. Members, \$2.00; nonmembers, \$4.00.

The basis for design, novel features, test program, and performance characteristics of a 100 MW gas turbine for either simple or combined cycle generation of electricity are presented. The details of the powerplant combustion chamber and turbine stages, and the conduct of its test and development program, are highlighted. O.C.

**A81-29948 # Engine maintenance cost calculation method.** C. E. Curry (General Motors Corp., Detroit Diesel Allison Div., Indianapolis, Ind.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-34.* 6 p. 13 refs. Members, \$2.00; nonmembers, \$4.00.

The Allison projected engine operating cost technique allows calculation of engine maintenance direct operating costs for various maintenance concepts and flying programs. Cost effects resulting from predicted or measurable effects of environment or mission constraints can also be calculated. This technique may be used to develop sensitivity analysis around nominal cost driver values. The technique discussed was designed for use with a hand-held programmable calculator. (Author)

**A81-29949 # Carbon/carbon components for advanced gas turbine engines.** L. Danis, S. Cruzen, and W. Schimmel (Williams Research Corp., Walled Lake, Mich.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-35.* 8 p. 9 refs. Members, \$2.00; nonmembers, \$4.00. DARPA-sponsored research.

A preliminary assessment is presented for carbon fiber/carbon matrix (C/C) composite materials applied to extreme temperature, limited life, uncooled turbine rotors intended for cruise missile expendable propulsion use. Although a major advantage of C/C composite materials over monolithic ceramics is their lack of brittleness, defect sensitivity and rapid fracture progression, oxidation and erosion protection remain essential development goals. Silicon carbide coatings are reported to have shown promise as oxidation barriers. Stress and temperature distribution data for a C/C turbine disk spinning at 60,000 rpm are presented. O.C.

**A81-29954 \* # Development of a low NO<sub>x</sub>/lean premixed annular combustor.** P. B. Roberts, A. J. Kubasco (Solar Turbines International, San Diego, Calif.), and N. J. Sekas (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-40.* 8 p. 9 refs. Members, \$2.00; nonmembers, \$4.00. NASA-supported research.

The results of an experimental atmospheric rig test program developed to define a low NO<sub>x</sub> annular combustor of 0.66 m diameter for high-altitude aircraft applications are presented. The test program strategy adopted evaluates the emission characteristics of a baseline configuration and subsequently examines the sensitivity of the emission signatures to variations in the key design features. The lean premixed combustor in axisymmetric annular form demonstrates the capability of operating at reduced-pressure, simulated high-altitude, supersonic cruise conditions with NO<sub>x</sub> emissions below 1.0 g NO<sub>2</sub>/kg fuel. The testing shows that for the full range of low emissions operation from idle to cruise, a variable dilution port system is necessary, but that fuel-switching can be avoided and a single fuel injection system used. L.S.

**A81-29955 # Premixing and flash vaporization in a two-stage combustor.** B. G. A. Sjoblom (Volvo Flygmotor AB, Trollhattan, Sweden). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-41.* 8 p. 9 refs. Members, \$2.00; nonmembers, \$4.00. Research supported by the Styrelsen for Teknisk Utveckling and Swedish Air Materiel Department.

A double recirculation zone two-stage combustor fitted with airblast atomizers has been investigated in a previous work. The present paper describes further tests with premixing tubes in the secondary combustion zone. Flash vaporization was employed to ensure complete vaporization of the secondary fuel, which was heated to 600 K by the combustor inlet air. The combustor was run at conditions corresponding to four different engine power settings, and the effect of primary/secondary fuel flow split on emissions was investigated. Tests were also performed with unheated secondary fuel, and comparisons were made with flash vaporization data. The best configuration reduced the oxides of nitrogen by 54 percent, carbon monoxide by 59 percent and unburned hydrocarbons by 97 percent as compared to emission levels for a standard combustor used as a reference. (Author)

**A81-29959 # Economics of heavy fuels in gas turbines and combined cycles.** L. O. Tomlinson and R. K. Alff (General Electric Co., Schenectady, N.Y.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-45.* 11 p. 6 refs. Members, \$2.00; nonmembers, \$4.00.

Operating experience has established the ability of gas turbines and combined cycles to utilize heavy fuel oils for power generation economically and reliably. The technical factors related to operation of gas turbines on heavy oils are discussed and installation and operating costs are developed for each of these factors for economic evaluation. Factors influencing heavy oil use include fuel specifications and treatment to prevent corrosion of hot parts, the effects of ash deposition on turbine nozzles and buckets and on boiler heat transfer surface, turbine and boiler cleaning techniques and their use for maintaining capability, and downtime for cleaning. (Author)

**A81-29962 # Some factors affecting altitude relighting performance of turbojet engine combustor.** T.-Y. Xiong, Z.-X. Huang, and Y.-Z. Wang (Academia Sinica, Institute of Engineering Thermophysics, Beijing, Communist China). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-49.* 15 p. 20 refs. Members, \$2.00; nonmembers, \$4.00.

Ignition performance of liquid fuel spray at various fuel/air ratios and the effect of gaseous fuel addition on ignition improvement were investigated on a gas turbine combustor test facility. Distribution of fuel/air ratio with gaseous fuel addition through the spark plug and the fuel nozzle into the flame tube was measured respectively. The universal ignition criterion derived from developed thermal explosion physical model at maximum chemical reaction rate for heterogeneous mixture ignition and the empirical formula of evaporation coefficient in fuel spray are in good agreement with experimental data obtained in dense and dilute fuel spray, and homogeneous mixture. (Author)

**A81-29965 # Improved particle trajectory calculations through turbomachinery affected by coal ash particles.** B. Beacher, W. Tabakoff, and A. Hamed (Cincinnati, University, Cincinnati, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-53.* 8 p. 6 refs. Members, \$2.00; nonmembers, \$4.00. Contract No. E(49-18)-2465.

Trajectories of small coal ash particles encountered in coal-fired gas turbines are calculated with an improved computer analysis currently under development. The analysis uses an improved numerical grid and mathematical spline-fitting techniques to account for three-dimensional gradients in the flow field and blade geometry. The greater accuracy thus achieved in flow field definition improves the trajectory calculations over previous two-dimensional models by allowing the small particles to react to radial variations in the flow properties. A greater accuracy thus achieved in the geometry definition permits particle rebounding in a direction perpendicular to the blade and flow path surfaces rather than in a two-dimensional plane. The improved method also accounts for radial variations in

airfoil chord, stagger, and blade thickness when computing particle impact at a blade location. (Author)

**A81-29970 # Full-flow debris monitoring in gas turbine engines.** T. Tauber (Technical Development Co., Glenolden, Pa.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-60.* 6 p. Members, \$2.00; nonmembers, \$4.00.

Filter screen-type and cyclonic-type full-flow debris monitoring devices for gas turbine engines are discussed. The most reliable and cost effective condition monitoring technique for gas turbine bearings and gears is found to be oil debris monitoring. Cyclonic debris separators are especially promising for ensuring early detection of impending failures when secondary damage is still minimal. In combination with a quantitative debris sensor, a full-flow monitor becomes a system which provides quantitative information about bearing deterioration. Given sufficient field experience, such a system will permit failure trending and prognosis. L.S.

**A81-29972 # Improved jet engine maintenance through automated vibration diagnostic systems.** R. A. Rio (Mechanical Technology, Inc., Latham, N.Y.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-62.* 6 p. Members, \$2.00; nonmembers, \$4.00.

Automated systems for balancing and diagnosing engine faults have been designed, developed, and successfully demonstrated in U.S. Air Force production jet engine overhaul facilities. Quality high-speed balancing of components will often reduce or eliminate the need for assembled engine balancing and reduce the rejection rate, thereby saving teardown, reassembly, and retesting costs. Stored engine sensitivity data can be used to calculate single-shot balance weights which, when installed, bring the engine vibration down to acceptable levels. The process reduces trim balance time to 1 hour and 20 minutes. The automated diagnostic system which utilizes vibration data from standard sensors demonstrates a 90% accuracy in predicting engine faults. The installed trim balancing and diagnostic system is projected to yield a multimillion dollar cost saving in its first year of operation. L.S.

**A81-29977 # Application of water cooling for improved gas turbine fuel flexibility and availability.** R. S. Rose, A. Caruvana, H. E. Doering, D. P. Smith (General Electric Co., Schenectady, N.Y.), and A. Cohn (Electric Power Research Institute, Palo Alto, Calif.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-68.* 7 p. 6 refs. Members, \$2.00; nonmembers, \$4.00. Research sponsored by the General Electric Co. and Electric Power Research Institute.

Near term application of water cooling to stage I nozzles on present day gas turbines results in significant improvements in fuel flexibility and performance. Design and performance calculations for application of a water-cooled stage I nozzle are compared to an air-cooled stage I nozzle in a heavy duty gas turbine. The results of ash deposition tests of both air-cooled and water-cooled nozzles using simulated residual fuel are presented for firing temperatures of 1850 F and 2050 F. This work was jointly sponsored by the Electric Power Research Institute and General Electric under the Advanced Cooling, Full-Scale Engine Demonstration Program. (Author)

**A81-29980 # Rotor-tip leakage. I - Basic methodology.** T. C. Booth, P. R. Dodge (AiResearch Manufacturing Company of Arizona, Phoenix, Ariz.), and H. K. Hepworth (Northern Arizona University, Flagstaff, Ariz.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-71.* 8 p. Members, \$2.00; nonmembers, \$4.00. Contract No. F33615-74-C-2017.

Blade tip losses represent a major efficiency penalty in a turbine rotor. These losses are presently controlled by maintaining close tolerances on tip clearances. This paper describes a series of

experiments and analyses which indicated a predominantly inviscid nature of tip leakage flow. The experiments were conducted on a series of three water flow rigs in which leakage quantities were measured over simulated blade tips. As a result of the experiments, a simple tip-leakage model is proposed that treats the normal velocity component in terms of discharge coefficient and conserves the tangential velocity (momentum) component. Identification of tip leakage controlled by a normal discharge coefficient suggests an optimum tip-treatment configuration may be designed through discharge testing of candidate configurations. A preliminary design optimization was conducted on the simple discharge rigs, and the results were evaluated on the water table cascade rig and on a turbine stage. (Author)

**A81-29981 # Rotor-tip leakage. II - Design optimization through viscous analysis and experiment.** A. R. Wadia and T. C. Booth (AiResearch Manufacturing Company of Arizona, Phoenix, Ariz.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-72.* 10 p. 13 refs. Members, \$2.00; nonmembers, \$4.00.

Experimental and numerical tip-leakage results are presented on a discharge coefficient parameter for five different tip configurations. Minimization of the discharge coefficient is achieved through viscous analysis for the perpendicular flow components and is supported by discharge-rig testing. The analysis for the discharge cross-flow uses a stream function-vorticity formulation. Results suggest superior performance with the winglet configurations. It is also shown that for the case of a turbine rotor, rotation will reduce leakage. V.L.

**A81-29982 \* # A simple model for compressor stall cell propagation.** N. A. Cumpsty (Cambridge University, Cambridge, England) and E. M. Greitzer (MIT, Cambridge, Mass.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-73.* 9 p. 10 refs. Members, \$2.00; nonmembers, \$4.00. Grant No. NsG-3208.

A simple model for full-span stall cells in axial compressors has been formulated. The sudden changes in velocity across blade rows as the blade passages enter and leave the stall are shown to have important dynamical consequences for the stall flow field. The one empirical constant needed in the analysis is determined using the data of Day (1976, 1978). From this, reasonable predictions of stall cell speed and trends in speed have been obtained for a number of different compressors. From the satisfactory comparison between predicted and measured stall cell speeds, it is tentatively concluded that the model contains the essentials of a correct description of the controlling mechanism of full-span rotating stall. (Author)

**A81-29984 # Cooling air flow characteristics in gas turbine components.** H. F. Jen and J. B. Sobanik (Avco Corp., Avco Lycoming Div., Stratford, Conn.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-76.* 8 p. 8 refs. Members, \$2.00; nonmembers, \$4.00.

An analytical model for the prediction of cooling air flow characteristics (mass flow rate and internal pressure distribution) in gas turbine components is discussed. The model addresses a number of basic flow elements typical to gas turbine components such as orifices, frictional passages, labyrinth seals, etc. Static bench test measurements of the flow characteristics were in good agreement with the analysis. For the turbine blade, the concept of equivalent pressure ratio is introduced and shown to be useful for predicting (1) the cooling air flow rate through the rotor blade at engine conditions from the static rig and (2) cooling air leakage rate at the rotor serration at engine conditions. This method shows excellent agreement with a detailed analytical model at various rotor speeds. A flow calibration procedure preserving flow similarity for blades and rotor assemblies is recommended. (Author)

**A81-29985 \* # Streamwise flow and heat transfer distributions for jet array impingement with crossflow.** L. W. Florschuetz, D.



## A81-29986

E. Metzger (Arizona State University, Tempe, Ariz.), and C. R. Truman. *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-77*. 10 p. 12 refs. Members, \$2.00; nonmembers, \$4.00. Grant No. NSG-3075.

Two-dimensional arrays of circular jets of air impinging on a heat transfer surface parallel to the jet orifice plate are considered. The air, after impingement, is constrained to exit in a single direction along the channel formed by the surface and the jet plate. The downstream jets are subjected to a crossflow originating from the upstream jets. Experimental and theoretical results obtained for streamwise distributions of jet and crossflow velocities are presented and compared. Measured Nusselt numbers resolved to one streamwise hole spacing are correlated with individual spanwise row jet Reynolds numbers and crossflow-to-jet velocity ratios. Correlations are presented for both inline and staggered hole patterns including effects of geometric parameters: streamwise hole spacing, spanwise hole spacing, and channel height, normalized by hole diameter. The physical mechanisms influencing heat transfer coefficients as a function of flow distribution and geometric parameters are also discussed.

(Author)

**A81-29986 # Inverse or design calculations for non-potential flow in turbomachinery blade passages.** W. T. Thompkins, Jr. and S. S. Tong (MIT, Cambridge, Mass.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-78*. 7 p. 10 refs. Members, \$2.00; nonmembers, \$4.00. Contract No. F49620-78-C-0084.

A new inverse or design calculation procedure has been devised for nonpotential flow fields and has been applied to turbomachinery blade row design. This technique uses as input quantities the surface pressure distribution and geometric constraints and may be used for two- or three-dimensional flows as well as inviscid or viscous flows. If a geometry satisfying both the constraints and the pressure distribution cannot be found, a solution satisfying the constraints and a relaxed pressure distribution is found. Calculational examples are presented for inviscid supersonic compressor cascade designs and the extension to three-dimensional flows discussed.

(Author)

**A81-29987 \* # Interactive multi-mode blade impact analysis.** A. Alexander (Hercules, Inc., Allegany Ballistics Laboratory, Cumberland, Md.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-79*. 11 p. Members, \$2.00; nonmembers, \$4.00. Contract No. NAS3-20091.

This paper describes the theoretical methodology used in developing an analysis for the response of turbine engine fan blades subjected to soft body (bird) impacts and the computer program that was developed using this methodology as its basis. This computer program is an outgrowth of two programs that were previously developed for the purpose of studying problems of a similar nature (a three-mode beam impact analysis and a multi-mode beam impact analysis). The present program utilizes an improved missile model that is interactively coupled with blade motion which is more consistent with actual observations. It takes into account local deformation at the impact area, blade camber effects, and the spreading of the impacted missile mass on the blade surface. In addition, it accommodates plate-type mode shapes. The analysis capability in this computer program represents a significant improvement in the development of the methodology for evaluating potential fan blade materials and designs with regard to foreign object impact resistance.

(Author)

**A81-29994 # A UK view on future fuels.** A. B. Wassell (Rolls-Royce, Ltd., Derby, England). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-87*. 6 p. 9 refs. Members, \$2.00; nonmembers, \$4.00.

Preliminary determinations concerning the impact of deteriorating gas turbine fuel specifications are reported, with stress on the replacing of kerosene by diesel fuel. Although trends agreeing with

previously published data for gaseous and black smoke emissions have been established, rig data at pressures greater than 20 bars from a tubular combustor suggest that increases in combustor liner temperatures may not have as great an impact on service life as has been supposed. General consideration is also given the production of 'white smoke' at sub-idle conditions and the impact of reduced thermal stability.

O.C.

**A81-29995 # Measurement of heat flux and pressure in a turbine stage.** M. G. Dunn (Calspan Advanced Technology Center, Buffalo, N.Y.) and A. Hause (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-88*. 10 p. 25 refs. Members, \$2.00; nonmembers, \$4.00. Contract No. F33615-79-C-2075.

Heat-flux and pressure data have been obtained for a full-stage turbine engine using state-of-the-art shock-tube technology and transient-test techniques. Comparisons are presented between a previous experiment with the stator-stage only and the full-stage data. The previous results are in good agreement with the full-stage data for the tip end-wall region, but they are significantly less than the full-stage results for the stator airfoil. The shroud heat flux is found to be independent of rotor chord position, but increases with increasing Reynolds number. The stage pressure data are in good agreement with the steady-state rig data obtained for this turbine.

V.L.

**A81-29997 # Sensitivity of turbine blade temperatures to tolerances of design variables.** E. S. Hsia (General Electric Co., Aircraft Engine Engineering Div., Evendale, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-90*. 9 p. Members, \$2.00; nonmembers, \$4.00.

The results of a study analyzing the blade temperature sensitivity of a single-stage, high-pressure turbine blade to variations in most design variables are reported. The effect on blade metal temperature of each variable was assessed individually, and the effect of changing several variables simultaneously was also determined. An equation was obtained on the basis of these results with which cumulative blade temperature effects can be predicted of single-variable sensitivities.

O.C.

**A81-30002 # The present role of high speed cascade testing.** J. P. Gostelow (New South Wales Institute of Technology, Broadway, Australia). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-95*. 14 p. 42 refs. Members, \$2.00; nonmembers, \$4.00.

The development of high speed cascade testing is traced and known high speed linear cascade tunnels are listed. The features of a good high speed cascade tunnel are discussed as are methods for obtaining adequate two-dimensionality and periodicity. Techniques for overcoming shock reflection problems in compressor and turbine cascades are described. Shock-boundary layer interactions require further investigation in compressor cascades and base-flow modelling in transonic turbine cascades. Instrumentation requirements and difficulties are discussed and the educational role of high speed cascade testing is emphasized.

(Author)

**A81-30003 \* # NASA research in aeropropulsion.** W. L. Stewart and R. J. Weber (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-96*. 11 p. Members, \$2.00; nonmembers, \$4.00.

NASA research activities in the development of civilian and military aircraft are discussed. The advances made in subsonic and supersonic transports, commuter aircraft, rotorcraft, V/STOL, and high-performance engines are reviewed, and the problems facing general aviation are considered. Comments on some new areas of technology are also presented.

L.S.

**A81-30006 \* #** Low NO<sub>x</sub>/ and fuel flexible gas turbine combustors. H. G. Lew, S. M. DeCorso, G. Vermes, D. Carl (Westinghouse Electric Corp., Concordville, Pa.), W. J. Havener (Westinghouse Electric Corp., Madison, Pa.), J. Schwab (Westinghouse Electric Corp., Pittsburgh, Pa.), and J. Notardonato (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-99.* 13 p. 12 refs. Members, \$2.00; nonmembers, \$4.00. Research supported by the U.S. Department of Energy; Contract No. DEN3-146.

The feasibility of various low NO<sub>x</sub> emission gas turbine combustor configurations was evaluated. The configurations selected for fabrication and testing at full pressure and temperature involved rich-lean staged combustion utilizing diffusion flames, rich-lean prevaporized/premix flames, and staged catalytic combustion. The test rig consisted of a rich burner module, a quench module, and a lean combustion module. Test results are obtained for the combustor while burning petroleum distillate fuel, a coal derived liquid, and a petroleum residual fuel. The results indicate that rich-lean diffusion flames with low fuel-bound nitrogen conversion are achievable with very high combustion efficiencies. L.S.

**A81-30007 #** Establishing cruise-engine cycle payoffs for a supersonic VSTOL aircraft. J. D. Cyrus (U.S. Naval Material Command, Naval Air Development Center, Warminster, Pa.), P. F. Piscopo, and R. T. Lazarick (U.S. Naval Air Propulsion Test Center, Trenton, N.J.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-100.* 8 p. 5 refs. Members, \$2.00; nonmembers, \$4.00.

Engine-aircraft-mission studies have been conducted by the Navy to establish changes in the weight and performance of supersonic VSTOL aircraft resulting from changes in the main cruise engine configuration, cycle characteristics, and complexity. The effects of engine component efficiency variations were quantified by a sensitivity analysis which identified performance changes on four different missions for a single engine aircraft. Studies of a twin engine aircraft with four different propulsion system configurations established the impact of changes in various cycle parameters on aircraft takeoff gross weight for the same three missions and identified thermodynamic and physical constraints for the cycles.

(Author)

**A81-30009 #** Modified Brayton cycles utilizing alcohol fuels. M. F. Bardon (Royal Military College of Canada, Kingston, Ontario, Canada). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-103.* 8 p. 14 refs. Members, \$2.00; nonmembers, \$4.00.

It is already well known that alcohols can be burned in open cycle gas turbines by direct firing in the combustor. This paper demonstrates however that there are significant improvements in thermal efficiency possible by modifying the manner in which alcohols are used in Brayton cycle engines. It is shown that injection of the alcohol during the compression process can materially improve both thermal efficiency and specific work because of the intercooling effect of evaporation. Calculations are given which demonstrate the improvement theoretically possible at representative values of peak turbine inlet temperature. It is also shown that the optimum pressure ratio for both regenerated and unregenerated cycles is different when such compressor evaporative intercooling is used rather than simply injecting the fuel into the combustor.

(Author)

**A81-30010 #** Effect of temperature dependent mechanical properties on thermal stress in cooled turbine blades. J. M. Allen (Westinghouse Electric Corp., Engineering Dept., Concordville, Pa.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-105.* 5 p. Members, \$2.00; nonmembers, \$4.00.

The effect of the temperature-induced variation in Young's modulus (E) and the coefficient of thermal expansion (alpha) on

thermal stresses in cooled gas turbine blades is investigated. The results of finite element analyses in which E and alpha are temperature dependent, and completely or partially independent of temperature are presented. The substantial differences are explained utilizing the solution for thermal stress in a flat plate with variable temperature through its thickness. Although the variation in E and alpha is small compared to the variation in temperature in thermal stress problems, it is shown that failure to take it into account can lead to large errors in thermal stress calculations. L.S.

**A81-30012 #** Flow transition phenomena and heat transfer over the pressure surfaces of gas turbine blades. A. Brown and B. W. Martin (University of Wales Institute of Science and Technology, Cardiff, Wales). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-107.* 10 p. 27 refs. Members, \$2.00; nonmembers, \$4.00. Research supported by the Science Research Council.

Detailed examination of flow measurements over concave pressure surfaces suggests that interaction of Taylor-Görtler vorticity with mainstream turbulent exerts only limited influence in enhancing laminar boundary-layer heat transfer. While transition is primarily controlled by the Launder laminarization criterion, the Görtler number at which it subsequently occurs is not solely determined by turbulence intensity. Adoption of K not less than 2.5 x 10 to the -6th (where K is the velocity gradient factor) as a design criterion for the pressure surfaces of turbine blades would appear to have significant advantages in terms of reduced heat transfer, increased lift, and lower aerodynamic drag. (Author)

**A81-30016 #** Life cycle cost before, during and after the design of aircraft propulsion systems. W. W. Shoemaker (General Electric Co., Cincinnati, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-111.* 11 p. Members, \$2.00; nonmembers, \$4.00.

A computerized life cycle cost model for aircraft engines is described. The use of the model in performing trade studies of new engine components with respect to the baseline engine is discussed with attention to the ways in which the model focuses on the interplay among the variables of cost, weight, and performance. The LCC computer model has also been used to examine detail tradeoffs among the materials and shapes used during the detail design of engine components as well as in the engine production phase. L.S.

**A81-30017 #** New features in the design of axial-flow compressors with tandem blades. K. Bammert (Hannover, Universität, Hanover, West Germany) and R. Staude (Maschinenfabrik Augsburg-Nürnberg AG, Oberhausen, West Germany). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-113.* 13 p. 11 refs. Members, \$2.00; nonmembers, \$4.00.

The application of tandem cascades in multi-stage axial flow compressors with 100% reaction blading is discussed with attention to the optimization of the tandem rotor blades. Design criteria are developed based on measurements obtained with a four-stage experimental compressor. The resulting concept for a multi-stage industrial compressor provides for the combined arrangement of compressor stages of single and tandem cascade design. The concept permits optimum performance to be achieved at a considerable cost reduction. As compared to conventional single cascades, the tandem cascade configuration is able to reduce flow losses by approximately 18%. L.S.

**A81-30018 #** Commercial engine logistics cost projections - A dynamic and flexible approach. N. C. Cavoli and G. J. Rokicki (United Technologies Corp., Commercial Products Div., East Hartford, Conn.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-114.* 10 p. Members, \$2.00; nonmembers, \$4.00.

An engine logistics cost projection system for forecasting maintenance cost factors for commercial airline operators is de-

scribed. The projection system is based upon engine part lives which are individually adjusted to account for differences in airline operations. The system uses a computer simulation program designed to project engine shop visits and maintenance materials costs. The method for describing part lives utilizing the Weibull analysis is outlined, and program flow diagrams are included. L.S.

**A81-30022 #** Development of the self-temperature compensated resistance strain gage used up to 700 C. Z. Zhi-qi and H. Pei-qing (Shenyang Aeroengine Research Institute, Shenyang, Communist China). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-118*. 7 p. Members, \$2.00; nonmembers, \$4.00.

This paper represents a self-temperature compensated resistance strain gage which is of combined type and developed recently. Because the scatter of the thermal output and the drift of the strain gage are smaller in all heat cycles, they could be compensated by bridge circuit or by dummy gage and better accuracy can be obtained. The gage enables engineers to measure the hot-end parts of aeroengines. (Author)

**A81-30032 #** New correlations of the two-dimensional turbine cascade aerodynamic performance. K. Qiang (Marine Boiler and Turbine Research Institute, Harbin, Communist China) and N. Chen (Academia Sinica, Institute of Engineering Thermophysics, Beijing, Communist China). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-128*. 8 p. 15 refs. Members, \$2.00; nonmembers, \$4.00.

Correlations are made between theoretical evaluations and experimental data for the performance of steam and gas (including turbocharger) turbines. On the basis of the high solidity, setting angle, and turning angle characteristics of turbine cascades, which facilitate the use of the channel concept, passage convergent gradient and tangential load coefficient criteria were chosen for cascade data correlation. Accurate semiempirical formulas for predicting the aerodynamic performance of cascades are formulated. O.C.

**A81-30033 \* #** Design and development of the combustor inlet diffuser for the NASA/GE energy efficient engine. P. E. Sabla, J. R. Taylor (General Electric Co., Evendale, Ohio), and D. J. Gauntner (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-129*. 9 p. Members, \$2.00; nonmembers, \$4.00. Contract No. NAS3-20643.

Results of an experimental investigation of the aerodynamic performance of a split duct annular combustor inlet diffuser system are presented. Several diffuser configurations were investigated in 3X-scale water table tests and the preferred design was evaluated in full-scale annular airflow model tests. Pressure recovery and flow losses were determined as a function of prediffuser inlet velocity profile, flow extraction at the prediffuser exit, and distribution of flow in the combustor. Inlet velocity profile and turbulence levels were found to have a pronounced effect on system performance. Flow extraction at the prediffuser exit was found to have little influence on system performance. Generally, the annular split duct diffuser system was found to satisfy the performance objectives for the engine. (Author)

**A81-30034 #** Design analysis of high-efficiency low-stress ceramic gas turbines. D. G. Wilson (MIT, Cambridge, Mass.) and L. Wood. *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-130*. 8 p. 14 refs. Members, \$2.00; nonmembers, \$4.00.

The gains which can be realized in gas-turbine cycles by lowering the pressure ratio, increasing the degree of regeneration, and utilizing multistage compressors and turbines, are much increased design-point thermal efficiency; very much higher part-load efficiency; and much reduced centrifugal stress, attachment stress, and foreign-object-damage stress. These gains, and the size penalty associated with this approach, are evaluated to a first approximation. The net benefits

should be substantial for many applications where size limits are not stringent, for instance trucks and boats, and where reduced fuel consumption is of paramount importance. (Author)

**A81-30035 #** An investigation of a preswirled cooling air-flow to a turbine disc by measuring the air temperature in the rotating channels. B. Meierhofer and C. J. Franklin (Gebr. Sulzer AG, Winterthur, Switzerland). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-132*. 8 p. Members, \$2.00; nonmembers, \$4.00.

The performance of a preswirled cooling air supply, to a turbine rotor, has been investigated by measuring the cooling air temperature relative to the rotor, in the rotating disc channels of a full size model. The effect of the following parameters was determined: nozzle height together with open circumference; nozzle to rotor spacing; distribution of the open circumference; disc secondary flows; induced cross-flows; axial air supply instead of preswirl. The results show the benefit of using preswirl to reduce the cooling air temperature relative to the rotating disc. They also show that the systems performance can be characterized by velocity triangles. The systems effectiveness was found to be a function of the disc velocity/effective preswirl velocity ratio. Of the parameters investigated only nozzle height and open circumference had any significant effect on system performance. (Author)

**A81-30039 #** A versatile microprocessor controller for low cost helicopter applications. N. A. Justice (Hawker Siddeley Dynamics Engineering, Ltd., Engine and Machinery Controls Div., Hatfield, Herts., England). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-137*. 8 p. Members, \$2.00; nonmembers, \$4.00.

Design criteria for microprocessor digital fuel controllers are examined with emphasis on environmental compatibility and the cost factors. A design concept is presented which employs a full authority simplex main control with inherent fail-freeze capability using fully independent backup analog speed/temperature limiters and a direct mechanical manual reversion throttle control system. A block diagram of the general controller configuration is presented. V.L.

**A81-30040 #** Using microprocessors in fault monitoring of aircraft electronics. A. Maybanks (Ultra Electronic Controls, Ltd., London, England). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-138*. 5 p. Members, \$2.00; nonmembers, \$4.00.

The Ultra Electronic Controls Fault Identification Module, as used in the Electronic Engine Control Unit (ECU) for the Olympus 593 engines of the Concorde Supersonic Transport Aircraft, is discussed. This is based on a CMOS microprocessor for low power consumption and enables the module to be applied to existing units without redesign of power supplies. The module examines the outputs of existing fault monitoring circuits and compares these with software-defined reference levels. It then determines, from this and other signals taken from the ECU safety consolidation circuits, the engine control subsystem which is at fault. This module has been in service for close to one year now and the impact on rapid and accurate fault diagnosis, elimination of premature ECU removals and thus reduction of cost ownership of the ECU is discussed. (Author)

**A81-30041 #** Full-authority digital electronic controls for civil aircraft engines. R. Kendell (Ultra Electronic Controls, Ltd., London, England). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-138*. 6 p. Members, \$2.00; nonmembers, \$4.00.

The application of full-authority digital electronic control (FADEC) systems for civil aircraft engines is in the formulation stage in the U.K. with the timescale for the FADEC programs aimed at starting detailed design during 1981. The paper discusses the major features that will be embodied in these new systems with particular reference to: (1) system tasks and performance requirements; (2)

configuration; (3) life cycle costing; (4) electronics design and system interfacing; and (5) reliability and integrity. K.S.

**A81-30053 #** A model for dynamic loss response in axial-flow compressors. M. R. Sexton (Virginia, University, Charlottesville, Va.) and W. F. O'Brien, Jr. (Virginia Polytechnic Institute and State University, Blacksburg, Va.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-154*. 7 p. 10 refs. Members, \$2.00; nonmembers, \$4.00. Navy-supported research.

An experimentally-determined dynamic loss response function was developed and incorporated in a model to predict the rotating stall behavior of an experimental compressor. The loss response model was developed employing Fourier transforms. The basis of the compressor model is a mathematical representation of the flow fields upstream and downstream of the compressor rotor. The compressor rotor is represented in the model by a semi-actuator disk. The results of the investigation show that the physical mechanisms which control the onset and propagation velocity of rotating stall in a single-stage compressor can be modeled with the use of the loss response function in a semi-actuator disk model of the compressor. The function represents the dynamic loss characteristics of the compressor rotor row, and provides important advantages over previous techniques. (Author)

**A81-30060 \* #** Fabrication of injection molded sintered alpha SiC turbine components. R. S. Storm, R. W. Ohnsorg, and F. J. Frechette (Carborundum Co., Niagara Falls, N.Y.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-161*. 6 p. 5 refs. Members, \$2.00; nonmembers, \$4.00. Research supported by the U.S. Department of Energy Contracts No. DEN3-17; No. DEN3-168; No. DEN3-167.

Fabrication of a sintered alpha silicon carbide turbine blade by injection molding is described. An extensive process variation matrix was carried out to define the optimum fabrication conditions. Variation of molding parameters had a significant impact on yield. Turbine blades were produced in a reasonable yield which met a rigid quality and dimensional specification. Application of injection molding technology to more complex components such as integral rotors is also described. (Author)

**A81-30064 #** The influence of blade number ratio and blade row spacing on axial-flow compressor stator blade dynamic load and stage sound pressure level. H. E. Gallus, H. Grollius, and J. Lambertz (Aachen, Rheinisch-Westfälische Technische Hochschule, Aachen, West Germany). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-165*. 9 p. 14 refs. Members, \$2.00; nonmembers, \$4.00.

In axial-flow turbomachines considerable dynamic blade loads and noise production occur as a result of the unsteady blade row interaction between rotor and stator blades. This paper presents results of midspan measurements of the dynamic pressure distribution on the stator blade surface (fixed number of blades) for various rotor-blade numbers and various axial clearances between rotor and stator. For this purpose, one stator blade had been provided with 11 semi-conductor pressure transducers in the midspan section. Simultaneously, the sound pressure level was measured at two axial distances downstream of the stator by four condenser microphones distributed along the circumference in each of the two sections and mounted flush with the wall surface. The wake-flow distribution downstream of the rotor could be obtained by a rotating three-hole pressure probe. The results of the corresponding dynamic pressure-measurements and noise measurements are discussed and compared with results from theory. (Author)

**A81-30078 \* #** Supersonic stall flutter of high-speed fans. J. J. Adamczyk, W. Stevans (NASA, Lewis Research Center, Cleveland, Ohio), and R. Jutras (General Electric Co., Evendale, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference*

*and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-184*. 8 p. 11 refs. Members, \$2.00; nonmembers, \$4.00.

An analytical model is proposed for predicting the onset of supersonic stall bending flutter in high-speed rotors. The analysis is based on a modified two-dimensional, compressible, unsteady actuator disk theory. The stability boundary predicted by the analysis is shown to be in good agreement with the measured boundary of a high speed fan. The prediction that the flutter mode would be a forward traveling wave sensitive to wheel speed and aerodynamic loading is confirmed by experimental measurements. In addition, the analysis shows that reduced frequency and dynamic head also play a significant role in establishing the supersonic stall bending flutter boundary of an unshrouded fan. L.S.

**A81-30082 #** The Navy PATE program. L. Greco (U.S. Navy, Naval Air Engineering Center, Lakehurst, N.J.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-189*. 7 p. Members, \$2.00; nonmembers, \$4.00.

The Navy Propulsion Automatic Test Equipment (PATE) program is described and specific areas of implementation are identified. It is noted that the program will adhere to the DOD direction to use the ATLAS language and that the NAVAIR Ground Support Equipment (GSE) community has initially chosen to implement the language on the DEC PDP11/34 minicomputer. C.R.

**A81-30084 #** Engine cycle selection for advanced technology engine studies. C. L. Lehman and V. J. Crafa (Grumman Aerospace Corp., Air Breathing Propulsion Section, Bethpage, N.Y.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-191*. 8 p. 6 refs. Members, \$2.00; nonmembers, \$4.00.

The Installed Propulsion Performance (IPP) and Propulsion Selection and Integration (PSI) programs are discussed. The IPP program interfaces with the source performance deck from the engine manufacturer to derive installed performance in a representative installation. Installation correction factors are selected from a large data bank with appropriate inlet, nozzle, engine air bleed, and horsepower extraction data selected from existing system designs and modified to the needs of the particular configuration. The PSI program is used to analyze propulsion system and mission performance. The internal design data routines of PSI are configured to generate an aircraft design consistent with engine dimensional, weight, and center of gravity characteristics. The program has several specialized subroutines to account for unique engine installations such as V/STOL. The results of studies using the IPP-PSI methodology are given for several high performance aircraft. L.S.

**A81-30086 #** Application of scaling in afterburner test and development. X.-Y. Li, M.-L. Yang, G.-E. Liu, and S.-J. Gu (Beijing Institute of Aeronautics and Astronautics, Beijing, Communist China). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-194*. 7 p. 6 refs. Members, \$2.00; nonmembers, \$4.00.

Experiments on low pressure combustion performance have been made with three different afterburner models. Tests were carried out in a test rig of 400 mm with inlet temperatures ranging from 898 to 940 K, inlet pressure from 0.77 to 1.51 kg/sq cm, and air flow rates from 4.06 to 8.26 kg/sec. The performance data (combustion efficiency and stability) obtained are similar to those obtained with the actual jet engine. Tests of a swirl atomizer and a plain orifice injector with the same fuel flow rates produced similar performance curves. In afterburner development work for a given type of engine, the effect on performance of changing from one type injector to another was less than that of changing stabilizers. (Author)

**A81-30090 #** Digital control makes a commercial debut on the JT9D engine. T. G. Lenox (United Technologies Corp., Commercial Products Div., East Hartford, Conn.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show,*

Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-199. 5 p. Members, \$2.00; nonmembers, \$4.00.

A digital electronic supervisory control system is incorporated in the JT9D-7R4 engine and is being applied in the new Boeing 767 and Airbus A310 aircraft. The digital control adjusts the governor setting of the hydromechanical fuel control to provide precise thrust management, rotor speed limiting and turbine temperature protection. A significant degree of integration with the aircraft has been established while maintaining separation of engine and aircraft control functions. The engine control receives air data computer information and other signals as used in the aircraft autothrottle control system for establishing power setting relative to engine thrust ratings. The engine control provides its own measurements both to validate air data computer information and to provide a back-up in the event that air data is interrupted. The control supplies digital information to the aircraft for cockpit display and maintenance purposes. The system has successfully completed Federal Aviation Administration certification testing and has initiated flight testing with the JT9D-7R4 engine. (Author)

**A81-30092 # A generalized mathematical model to estimate gas turbine starting characteristics.** R. K. Agrawal and M. Yunis (Pratt and Whitney Aircraft of Canada, Ltd., Longueuil, Quebec, Canada). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-202.* 8 p. Members, \$2.00; nonmembers, \$4.00.

The paper describes a generalized mathematical model to estimate gas turbine performance in the starting regime of the engine. These estimates are then used to calculate the minimum engine starting torque requirements, thereby defining the specifications for the aircraft starting system. Alternatively, the model can also be used to estimate the start up time at any ambient temperature or altitude for a given engine/aircraft starting system combination. (Author)

**A81-30093 \* # Effect of time-dependent flight loads on turbobfan engine performance deterioration.** B. L. Lewis (Teledyne, Inc., Teledyne CAE, Toledo, Ohio), A. Jay (United Technologies Corp., Commercial Products Div., East Hartford, Conn.), and E. G. Stakolich (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-203.* 6 p. 8 refs. Members, \$2.00; nonmembers, \$4.00. Contract No. NAS3-20632.

An analytic evaluation of the dynamic effects of two flight load conditions of the JT9D-7/747 propulsion system is conducted. Predicted performance changes associated with a once-per-flight vertical gust and a typical revenue service landing are calculated. The predicted dynamic load effects on thrust specific fuel consumption are found to be negligible. The results indicate that the quasi-steady state approach to flight loads modeling is adequate to investigate the factors important to the deterioration process. L.S.

**A81-30096 # Semi-inverse method of computation in inviscid transonic flows - Application to the design of turbomachines blades profiles.** H. Miton (Aix-Marseille I, Université, Marseille, France). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-206.* 9 p. 10 refs. Members, \$2.00; nonmembers, \$4.00.

The present method is based on an original computational technique of quasi two-dimensional inviscid flows but which takes into account the changes of entropy due to shocks. The present approach consists in a numerical 2nd order approximation of the real transonic flow problem (hyperbolic or elliptic) by an initial values problem of hyperbolic and parabolic nature respectively. Such a method applied to the flow field between two adjacent blades profiles allows starting from a prescribed distribution of velocity along blade pressure or suction side to determine the flow details inside this domain and the profile of the opposite blade wall corresponding to input flow conditions which however should be made to satisfy the periodicity conditions as at this stage the

approach is of the channel type. Examples of computation for simple cases are shown which proves the validity of the method. (Author)

**A81-30097 \* # NASA gas turbine stator vane ring.** H. M. Gersch (AiResearch Casting Co., Torrance, Calif.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-208.* 6 p. Members, \$2.00; nonmembers, \$4.00. NASA-sponsored research.

Four monolithic stator vane rings from reaction-bonded silicon nitride were produced. This paper describes the various steps involved: wax injection of stator vane patterns, precise fixturing of patterns, mold fabrication, slip preparation, casting, prenitriding, nitriding, and ceramic machining. Each process step is discussed and illustrated, and tables of property measurements are included. (Author)

**A81-30098 # Experimental investigation of a low hub-to-tip ratio single stage transonic fan.** Y.-B. Wei, B.-C. Dong, and G.-X. Zhang (Shenyang Aeroengine Research Institute, Shenyang, Communist China). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-209.* 10 p. 6 refs. Members, \$2.00; nonmembers, \$4.00.

A preliminary analysis of a single-stage transonic fan with a hub-to-tip ratio of 0.385 is presented in this paper. The flow field design computer program and the parameter selection of the fan parameters are reviewed. The modifications which should be made to improve the performance of the fan are pointed out. The experimental results demonstrate that the overall performance design goals of the fan have been achieved at design speed and flow rate. But fan discharge total pressure and total temperature gradients still exist and efficiency is poor at the hub and tip regions. Therefore the single stage fan is not suitable for use as an inlet stage. The main reason for the problems mentioned above are the inaccurate calculation of flow field and inadequate selection of design parameters. (Author)

**A81-30102 # Cooled radial in-flow turbines for advanced gas turbine engines.** J. M. Lane (U.S. Army, Applied Technology Laboratory, Fort Eustis, Va.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-213.* 9 p. 9 refs. Members, \$2.00; nonmembers, \$4.00.

It is noted that while the radial in-flow turbine has consistently demonstrated its capability as a high-performance component for small gas turbine engines, its use has been restricted to lower turbine-inlet-temperature cycles. This is because of insurmountable problems regarding the manufacture of radial turbine rotors having internal cooling passages. It is pointed out that these cycle temperature limitations are inconsistent with modern trends toward higher-performance, fuel-conservative engines. The results of several Army-sponsored programs are presented, the first of which deals with the performance potential for the high-temperature radial turbine. The results of two successful programs for developing fabrication techniques for internally cooled radial turbines, including mechanical integrity testing, are also discussed. C.R.

**A81-30104 # The role of flight research vehicles in prop-fan technology development.** E. S. Bradley and B. H. Little, Jr. (Lockheed-Georgia Co., Marietta, Ga.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 9-12, 1981, Paper 81-GT-216.* 11 p. Members, \$2.00; nonmembers, \$4.00.

The prop-fan concept offers the potential for significant fuel savings without reducing aircraft performance from the levels of current turboprop aircraft. To enhance industry acceptance of the concept there is a need to accelerate current research and development activities. This paper describes how flight research vehicles could be used in an advanced turboprop, or prop-fan, program. The technology status of prop-fan development is reviewed and deficiencies are identified. Methods for solving prop-fan problems using the test-bed aircraft philosophy are discussed. Based on defined problem

areas which must be addressed if the prop-fan is to become an accepted propulsion system, test-bed program objectives and priorities are established, and the design requirements for a prop-fan research vehicle are formulated. Suitable configurations are examined and analyzed. (Author)

**A81-30151 #** Test-stand combustion chamber for the study and development of forced working processes (Stendovaia kamera sgoraniia dlia issledovaniia i otrabotki forsirovannykh rabochikh protsessov). I. P. Goldaev, A. P. Pershin, A. I. Iudin, and V. Iu. Latka. *Samoletostroenie - Tekhnika Vozdushnogo Flota*, no. 47, 1980, p. 10-13. In Russian.

The paper reports the development of an experimental jet-engine combustion chamber for the investigation of working processes. A modular construction is used which simplifies and speeds up the work of experimentation. The test stand is shown to be a suitable tool for the design and development of jet-engine combustion chambers. P.T.H.

**A81-30152 #** Interaction of a gas jet from a jet engine with the destroyed surface of a multiphase disperse medium (Vzaimo-deistvie strui gaza dvigatel'ia reaktivnogo tipa s razrushaemoi poverkhnost'iu mnogofaznoi dispersnoi sredy). A. P. Motornenko and V. A. Sheryshev. *Samoletostroenie - Tekhnika Vozdushnogo Flota*, no. 47, 1980, p. 13-17. In Russian.

A theoretical examination is presented of the interaction of the gas flow from a jet engine and a multiphase disperse medium. Equations are obtained which relate the parameters of the gas jet and the intensity of destruction of the fluid/solid particle medium. Theoretical results agree well with experimental results on the destruction of a multiphase surface by a supersonic gas jet. P.T.H.

**A81-30153 #** Test stand for the experimental study of auxiliary power supplies (Stend dlia eksperimental'nykh issledovaniy agregatov vspomogatel'nykh istochnikov moshchnosti). I. P. Goldaev, V. V. Il'inskii, and E. A. Skovorchevskii. *Samoletostroenie - Tekhnika Vozdushnogo Flota*, no. 47, 1980, p. 17-21. In Russian.

The paper describes the design and operation of a test stand intended for the experimental study of aircraft auxiliary power supplies. The stand consists of a pneumatic compressed-air supply system, a gas generator, and hydraulic and electric automatic systems of actuation, control, and data recording. Design diagrams of the stand are presented. P.T.H.

**A81-30155 #** Driving dynamics of a high-speed positive-displacement pump and gas-turbine drive during startup (Dinamika raskrutki vysokoborotnogo ob'emnogo nasosa i privodnoi gazovoi turbiny pri zapuske). E. A. Skovorchevskii. *Samoletostroenie - Tekhnika Vozdushnogo Flota*, no. 47, 1980, p. 26-30. 6 refs. In Russian.

An analysis is presented of the driving period of a high-speed displacement pump, driven by a gas turbine; the pump is part of the power-supply unit for an aircraft hydraulic stabilization and control system. It is found that pressure unloading of the displacement pump and repeated gas delivery to the working wheel of the turbine can considerably shorten the time of driving and improve the response speed of the entire system. P.T.H.

**A81-30156 #** Faults of helicopter hydraulic amplifiers related to loading characteristics (O neispravnostiakh gidrousilitelei vertoletov v sviazi s osobennostiami ikh nagruzheniia). Iu. S. Golovko and V. P. Bocharov. *Samoletostroenie - Tekhnika Vozdushnogo Flota*, no. 47, 1980, p. 30-34. 5 refs. In Russian.

An analysis is presented of the loading characteristics of helicopter steering gears. Attention is given to the influence of the constant and variable loading components on the actuation units of the steering gears, as well as to the influence of helicopter vibration and instability on helicopter control. A description is given of hydraulic amplifier faults, determined by loading characteristics in

the control system. The characteristic structural parameters of the steering gears are analyzed. P.T.H.

**A81-30158 #** Complex computation of flywheel power systems for flight vehicles (Kompleksnyi raschet makhovichnykh energosistem letatel'nykh apparatov). N. F. Sviridenko. *Samoletostroenie - Tekhnika Vozdushnogo Flota*, no. 47, 1980, p. 37-41. 5 refs. In Russian.

A theoretical analysis is presented of the operation of a power system consisting of a flywheel, and a stable-frequency current generator of stepless transmission design. A complex computation method is developed for the determination of the load and kinematic characteristics of the stepless transmission, and the moment of inertia of the flywheel; the method ascertains whether the system meets energy consumption requirements. P.T.H.

**A81-30159 #** The problem of hoar-frost formation in aircraft fuel tanks (K voprosu ineobrazovaniia v samoletnykh toplivnykh bakakh). G. S. Matusevich, N. V. Kapralov, and S. L. Manita. *Samoletostroenie - Tekhnika Vozdushnogo Flota*, no. 47, 1980, p. 41, 42. In Russian.

Particular cases of hoar-frost formation on fuel tank walls during fuel cooling are considered. It is shown that the addition of small quantities of antiicing substances to the fuel will lead to the formation of a supercooled condensate that is easily washed off by the fuel. P.T.H.

**A81-30160 #** Evaluation of the effect of actuator time lag on the minimum control power of a VTOL aircraft (K otsenke vliianiia inertsiionnosti ispolnitel'nykh elementov na potrebnuiu moshchnost' upravleniia AVVP). O. A. Artemov. *Samoletostroenie - Tekhnika Vozdushnogo Flota*, no. 47, 1980, p. 43-46. 5 refs. In Russian.

The paper considers the optimal control of angular maneuver of a VTOL aircraft, taking into account the actuator time lag. A relationship is obtained between the control power necessary to perform the maneuver in minimum time and the time constant of the actuators. P.T.H.

**A81-30163 #** Optimization of finishing conditions (Optimizatsiia rezhimov obrabotki). S. A. Shchipelev. *Samoletostroenie - Tekhnika Vozdushnogo Flota*, no. 47, 1980, p. 73-77. In Russian.

Optimal metal-cutting conditions are investigated, the optimization criterion being the area of removed material as a function of cutting rate and path. A nonlinear model of the cutting process with an explicit extremum is obtained. It is suggested that direct search without Hooke-type constraints be used to determine the extremum. It is concluded that the proposed method for finding optimal cutting conditions is especially suitable in automatic optimization systems. P.T.H.

**A81-30164 #** The possibility of single-impact riveting of flat-top countersunk-head rivets (O vozmozhnosti odnoudarnoi kleпки s obrazovaniem potainoi zamykaiushchei golovki). I. G. Fedosenko, V. S. Lepetiukha, and V. G. Chistiak. *Samoletostroenie - Tekhnika Vozdushnogo Flota*, no. 47, 1980, p. 78-80. In Russian.

The application of single-impact riveting techniques to fuselages, with the utilization of single-impact countersunk-head rivets, is considered. The single-impact approach is found to improve the hermeticity and durability properties of the riveted joints. P.T.H.

**A81-30168 #** Classification of links of assembly units with respect to the character of their connections, and calculation of the accuracy of their execution (Klassifikatsiia sopriazhenii sborochnykh edinit po kharakteru svyazei i raschet tochnosti ikh vypolneniia). Iu. A. Boborykin, A. I. Babushkin, and N. M. Parkhomenko. *Samoletostroenie - Tekhnika Vozdushnogo Flota*, no. 47, 1980, p. 92-95. In Russian.

An engineering design analysis of the linking of assembly units in the construction of an airframe is carried out on the basis of a

classification of links with respect to the character of connections. A functional relationship is presented for calculating the total error of the overall connecting link. The classification of links can be used to determine the most cost-effective tolerances in the fabrication of the assembly units. P.T.H.

**A81-30238**      **Advanced techniques for airborne target screener.** D. P. Panda and R. K. Aggarwal (Honeywell Systems and Research Center, Minneapolis, Minn.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 108-113. 8 refs. DARPA-USAF-sponsored research.

A context dependent automatic image recognition system has been developed for detecting tactical and strategic targets. The system features sequential frame processing, symbolic image segmentation, syntactic recognition, recognition of multicomponent objects, and conflict removal. In experimental analysis, the target screener system has recognized small image and large image tanks, trucks, and vehicle convoys under various conditions of contrast, clutter, aspect angle, occlusion, and range-to-target. V.L.

**A81-30239**      **An MTI /moving target indicator/ algorithm for passive sensors.** R. D. Holben (Ford Aerospace and Communications Corp., Aeronutronic Div., Newport Beach, Calif.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 114-121.

An algorithm has been developed to compensate for apparent background motion in images taken from a moving platform by a passive sensor. The algorithm involves actual background tracking by comparing subregions from two images, development of a velocity model for predicting the appearance of a later image, comparison of the predicted and measured images, and extraction of objects that did not move with the background. Successful scene registration and moving target extraction has been demonstrated for several sequences of images taken from an airborne FLIR. V.L.

**A81-30240 #**      **Air Force Integration Support Facilities - Their total utility.** A. E. Patterson (USAF, Sacramento Air Logistics Center, McClellan AFB, Calif.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 126-135. 9 refs.

Integration Support Facilities (ISFs) are being developed with the objective of supporting the Embedded Computer System (ECS) software and integrating ECS hardware/software after acquisition and during operation. The principal tools of ISFs include: ECS mockups, automatic test equipment mockups, dynamic simulators, host computer system, and prototype fabrication tools. The F-111 ISF is described as an example of the utility an ISF provides to a weapon system. V.L.

**A81-30241 #**      **Augmenting ATE with dynamic simulation testing techniques.** A. Carneiro and E. M. Long (USAF, Sacramento Air Logistics Center, McClellan AFB, Calif.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 136-142.

Test aids have been developed which provide a capability to duplicate, detect, and isolate time dependent and intermittent flight line reported problems. This capability augments the existing automatic test equipment. The aids are capable of interfacing the system boxes as a system and providing dynamic system level testing. The test aid concept has been developed for the F-111 digital avionics system but is readily adaptable to other systems with similar problems. V.L.

**A81-30243 #**      **Avionics computer system support at Ogden ALC.** D. V. Thornell (USAF, Ogden Air Logistics Center, Hill AFB, Utah). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 148-151.

The efforts of Ogden Air Logistics Center in developing an in-house, government operated engineering support capability for the selected F-4 and F-16 Operational Flight Program (OFP) are discussed. The primary tasks have been: (1) to assist the program manager in his efforts to ensure that the Embedded Computer System (ECS) being acquired fulfilled its technical performance requirements, (2) to determine the ECS life cycle support concept to be employed (i.e., government, organic or contractor, on base or in plant), (3) to develop the government personnel ECS expertise necessary to support the OFPs in the manner chosen, and (4) to acquire the ECS support tools required by the ECS support concept chosen. ALC experience with these tasks is discussed, and some recommendations to contractors are made, including the advice to design ECS development equipment to be compatible with Air Force ECS maintenance equipment requirements and to include an ECS Training and Transition Plan as an option in the production contract. D.K.

**A81-30245**      **Design and development of the control laws for the F-18 primary flight control system.** R. L. Kisslinger, W. J. Momeno, and J. M. Urnes (McDonnell Aircraft Co., St. Louis, Mo.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 158-165.

Based on the availability of airborne digital processors, digital rather than analog processing was used for the flight control computations of the F-18. The design of the system progressed from a continuous domain functional definition to an operational flight program through a series of iterative steps. Extensive use of interactive graphics allowed rapid convergence on solutions to problems, as well as a means of checking flight simulator and 'iron bird' laboratory computer versions of the system. Pitch, yaw and roll axis analyses and control law synthesis are detailed. O.C.

**A81-30246**      **YC-14 digital flight control experience.** D. L. Martin (Boeing Military Airplane Co., Seattle, Wash.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 166-173. 7 refs.

The major goals driving the configuration design of the YC-14 digital flight control system and the resulting operational characteristics of the aircraft are described. Impressive STOL performance and excellent flying qualities have been demonstrated with the triplex digital flight control design, which provides high authority command and stability augmentation and unique control modes for the tactical transport mission. Preliminary design, development and testing are discussed, with stress on the redundancy management concept that has extended fail-operational, fail-passive methods to the tactical transport flight envelope. O.C.

**A81-30248**      **Digital flight control - The generation of the 80's.** J. L. Lockenour, I. Saworotnow, and D. F. Kesler (Northrop Corp., Aircraft Div., Hawthorne, Calif.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 182-190.

Primary contemporary problems, a description of future multi-processor architectures, and suggestions for future research and development of digital flight control systems for fighter aircraft are presented, from the point of view of the airframe manufacturer. The first generation of fly-by-wire, and digital flight control systems have in many cases been overly complicated and expensive with actuator



and input signal management, software development, and fault isolation some of the major problems. The flight control system of the 80s will see changes in system architecture, as well as in the type and nature of the chip level components. The low cost of military qualified hardware will drive systems toward more hardware intensive solutions. Redundant fault-tolerant microcomputers on a chip will have a major impact and CMOS and multiplexing chips will allow the total flight control computer size to match the progress in microelectronics more closely. The major challenges of the 80s are to standardize the software/hardware architecture, and to accommodate the logical systems level integration with the mission avionics. K.S.

**A81-30249 Delco Electronics Flight Management System for Air Force C-141 aircraft.** R. Farmer (General Motors Corp., Delco Electronics Div., Santa Barbara, Calif.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 191-198.

Following several years of flight testing and operation in 747 and DC-10 airliners that have demonstrated considerable fuel savings, the Delco Flight Management System (FMS) is being considered by the Air Force for its cargo and strategic aircraft. Fuel savings of 60 million gallons annually are estimated, and engine maintenance cost savings are also expected. The electronic components of the system, its integration and functional interaction with aircraft controls, and its flight path optimization computation methods, are discussed in detail. O.C.

**A81-30250 Dispersed flight control computer systems.** T. E. Newman (Grumman Aerospace Corp., Bethpage, N.Y.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 204-210. Contract No. F33615-77-C-3041.

The results of analyses and trade-off studies aimed at selecting a practical and cost-effective dispersed digital computer configuration, which will increase both the survivability and the failure tolerance of future flight control systems, are presented. Using the F-14 fighter as a baseline aircraft, the characteristics of four candidate dispersed computer configurations are analyzed in light of system requirements relating to hardware, software, size, and weight. It is concluded that a quad redundant central computer configuration is optimum for a dispersed flight control system in an advanced fighter-attack aircraft. O.C.

**A81-30252 The Z8000 provides the basis for a powerful new airborne computer.** C. F. Newby (General Dynamics Corp., Convair Div., San Diego, Calif.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 222-230.

The hardware architecture and application-oriented software support mechanisms of a Z8002-based airborne computer are described. The design incorporates recent advances in large-scale integration (LSI) technology that allow a low-cost, high-throughput computer to operate reliably under severe conditions despite weighing less than six pounds, requiring 50 watts of power, and occupying 150 cu in. The hardware is based on the Z8002 16-bit microprocessor, and is supported with assembly language, PL/Z, and the JOVIAL J-73 high-level language. O.C.

**A81-30258 Advanced avionic systems for multi-mission applications.** L. A. Smith and D. E. Dewey (Boeing Military Airplane Co., Seattle, Wash.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 284-290. Contract No. F33615-77-C-1252.

A technology-forecast study considers the role of the next five

years' developments in microprocessors and LSI circuitry in avionics systems, information transfer system designs allowing avionics additions without modification, and Air Force standards on microprocessors. Cost models for hardware and software and information transfer system simulation models were also reviewed for possible use in the study, which has resulted in the definition and analysis of stationary and nonstationary master and contention multiple access data bus information transfer systems allowing multimission applications. It is concluded that if a single military standard computer is selected, it will be built from bit-slice microprocessors and have substantially more parts than militarized versions of single-chip microprocessors. O.C.

**A81-30259 Offensive avionics system /OAS/ design.** A. G. Cameron (Boeing Military Airplane Co., Wichita, Kan.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 296-306. USAF-sponsored research.

Presented is an airborne computer controlled electronics system to fulfill the Air Force Strategic Air Command need for near term, cost effective improvements to the B52G/H Offensive Avionics. The OAS achieves an effective combination of improved performance, lowered life cycle cost and compatibility with retained B-52 systems through emphasis on careful subsystem selection and efficient digital electronics. New and modified advanced technology sensors are interfaced with retained systems to provide the Navigation and Guidance Subsystem. The new Computational Subsystem features full redundancy through two identical digital computers, four data transfer units, and a redundant Data Bus Communication Network. This computational capability will support the Navigator and Radar Navigator in system management and control with accurate, high speed information processing. (Author)

**A81-30261 Failure detection and isolation for tactical aircraft using the generalized likelihood test.** P. R. Motyka (Charles Stark Draper Laboratory, Inc., Cambridge, Mass.) and J. W. Bell (USAF, Avionics Laboratory, Wright-Patterson AFB, Ohio). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 312-321. 6 refs. Contract No. F33615-78-C-1563.

This paper addresses the development and evaluation of a failure detection and isolation (FDI) system for tactical aircraft operating in a dynamic flight environment. The FDI approach selected is the generalized likelihood test (GLT). The algorithm has the capability to detect and isolate both hard and soft failures. Performance in the presence of soft failures, which affect the navigation and precise weapon delivery performance of tactical aircraft, is emphasized. The maneuvering environment requires variable failure detection thresholds to prevent false alarms. A technique is presented for generating dynamic thresholds as a function of the sensor error models, maximum values of the sensor errors, and the body axes linear accelerations or angular rates. The multifunction inertial reference assembly (MIRA) concept is employed. Laser gyro models are used. The sensor configuration is a symmetric conical array of five instruments. Results are presented which show the operation of the FDI system over a spectrum of sensor failures and indicate the effect of these failures on the tactical aircraft system. Digital simulation was used extensively. (Author)

**A81-30264 Flight control system design through constrained output feedback.** E. Y. Shapiro and R. H. Rooney (Lockheed-California Co., Burbank, Calif.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 341-345. 7 refs.

A method is presented for the direct determination of the control law that transfers the poles of a given system to a set of

desired poles, representing acceptable aircraft control characteristics. The method depends on the minimization of a function defined as the distance between the ordered sets of original and desired eigenvalues. In the absence of a closed-form analytical expression for the gradient of this function, the needed gradient is computed numerically. Function minimization is computed by means of a Davidson-Fletcher-Powell algorithm. O.C.

**A81-30265** The use of finite-state machines for describing and validating flight control systems. E. R. Rang (Honeywell, Inc., Minneapolis, Minn.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 347-353. 8 refs.

A basic flight control system was specified as a two-level hierarchy of finite-state machines. The system states were defined by the servo and flight director engagements; substates were defined by the control mode calculations. No distinction was made between hardware and software functions in the top-level description. The second-level description defined the hardware-software allocation. Further refinements defined the software structure of the flight control modes. This approach allows precise and complete functional specifications which are easily reviewed by the flight control designer and the software implementer. These specifications form the basic document for subsequent design of the software. The structure may be completely verified and validated at any stage of the development process and provides a framework for the final software/hardware validation. (Author)

**A81-30266** KC-10A refueling boom control system. R. van't Riet and F. R. Thomas (Douglas Aircraft Co., Long Beach, Calif.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 354-361.

The development of a fly-by-wire refueling boom for the KC-10A tanker is described, with attention to the 'rolling boom' concept used to obtain wide lateral motion capability. The details of the configuration, an explanation of the controllability challenges posed by the task of in-flight refueling, and the control laws employed and their mechanical realization are reviewed. Also presented are software validation methods for the design, and the results of a prototype boom test program. O.C.

**A81-30274** Contention information transfer systems analysis. M. E. McSharry and L. A. Smith (Boeing Military Airplane Co., Seattle, Wash.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 420-426. 5 refs.

A contention information transfer system (ITS) is one in which the decision to transmit on a sheared data bus is made independently by each device that has information to transmit. It is desirable because no single device is relied upon for the ITS operation, all devices linked via the ITS remain functionally isolated, and subsystems integration/modifications is most easily accommodated by the independence and simplicity of its operation. An analysis of three types of contention ITS is presented with particular reference to their use in commercial and military aircraft. The most significant difference among the three is the technique used to determine the availability of the transmission line. The emergence of the optical data bus and LSI hardware makes such an ITS feasible and it should be cost effective. The selection of a particular contention ITS is driven by system requirements of throughput, message reliability, and cost. K.S.

**A81-30284** Lightning threat definition for aircraft electrical power systems. D. G. Fox (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, Ohio) and W. P. Geren (Boeing Military Airplane Co., Seattle, Wash.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May

20-22, 1980. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 562-577. 8 refs. Contract No. F33615-79-C-2006.

The interaction of lightning-induced fields with the avionics systems of fighters, fighter-bombers, and cargo aircraft is modeled by a methodology derived from standard electromagnetic coupling techniques. The coupling mechanisms considered are: (1) direct capacitive coupling to exposed wiring, (2) coupling through apertures (windows and doors), (3) diffusive coupling through composite structure, and (4) coupling through joints. The calculation of the threat posed by lightning yields a quantitative determination of the likelihood of circuit damage and provides design requirements for lightning protection. Both metallic and composite-structure aircraft are considered. O.C.

**A81-30285** Digital computer simulation of generalized fault conditions on aircraft electrical power systems. J. Dhyanchand and R. Arbanella (Sundstrand Corp., Sundstrand Advanced Technology Group, Rockford, Ill.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 578-584. 7 refs.

A computer digital analysis developed to calculate the fault conditions of aircraft electrical generating systems during conventional high impedance faults is discussed. The simulation uses the well-known symmetrical component theory and analyzes the fault conditions of the system during the following possible faults: (1) single line to neutral fault through a fault impedance, (2) line to line fault through a fault impedance, (3) double line to neutral fault through a fault impedance, and (4) three line to neutral fault through a fault impedance. The simulation procedure has three assumptions: (1) the induced airgap voltage is balanced and sinusoidal during the faults and unbalanced loading, (2) the saturation of magnetic material is not included in the analysis, and (3) the speed of the generator is constant. Some applications shown are a steady state simulation of unbalanced loads and a steady state simulation of fault conditions to coordinate breakers and undervoltage time delay. D.K.

**A81-30289** Program Navigate - A simulation computer program to verify OAS navigation capability. T. W. Lezniak (Boeing Military Airplane Co., Wichita, Kan.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 616-621. USAF-supported research.

Program Navigate is a full-valued, Monte Carlo simulation of the OAS (Offensive Avionics System) navigation system. The primary roles for the simulator are: to provide quantitative verification of the navigation design; to assist in the testing and integration of flight navigation software; to provide detailed simulation capability for the investigation of anomalies encountered in flight test; and to provide detailed simulation capability for performance estimation on missions which cannot be flown during flight test. The simulator is composed of a navigation section, a reference section, a sensor simulation section, a control section, and an input/output section; extensive post-run analysis software also exists. Properties and capabilities of the various sections of the simulator are discussed in detail. Examples of the options available to the user flying the simulator are presented, and an example of the navigation system performance computed by the simulator and analyzed and graphed by supporting software is also presented. (Author)

**A81-30290** Simulation of a third-order vertical channel mechanization. M. T. Lu (Boeing Military Airplane Co., Wichita, Kan.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 622-626. 6 refs. USAF-supported research.

A design study of the vertical channel mechanization for an airplane's inertial navigation system has been conducted for applica-

tion to the B-52 Offensive Avionics System. This vertical channel has been mechanized for third-order constant gains and utilizes a multisensor air data altitude. Optimization of parameters and accuracies in altitude and vertical velocity were analyzed. Computer simulation runs were also conducted. (Author)

**A81-30291** Satellite constellations for three-dimensional coverage of the Atlantic Ocean. S. M. El-Sagor, E. I. Sabry, and C. R. Carter (McMaster University, Hamilton, Ontario, Canada). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 2.

New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 627-634. 6 refs. Research supported by the Natural Sciences and Engineering Research Council of Canada.

The ground coverage pattern of a geosynchronous satellite dedicated to ship and aircraft navigation service is determined, as a function of the locus of the satellite subpoint and its instantaneous coverage area. The locus of the subpoint is shown to be a function of the inclination angle of the orbital plane. The problem of three-dimensional position determination using satellites is analyzed, and the factors influencing satellite configuration are discussed. Five satellite constellations are proposed for three-dimensional continuous coverage of the Atlantic Ocean in which overall coverage patterns and continuous coverage areas for different time periods are defined. A comparison of the different constellations is presented with attention to the problems associated with three-dimensional position location. O.C.

**A81-30293** Optimal tracking design and simulation for a monopulse airborne radar system utilizing a predicted dual beam antenna design. M. A. Mayor (E-Systems, Inc., ECI Div., St. Petersburg, Fla.) and S. J. Garrett (South Florida University, Tampa, Fla.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 2.

New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 645-652.

An optimal digital controller is designed for target tracking in an amplitude sensing monopulse system. The optimal digital control system has been designed to minimize a quadratic performance index. The details of the design, including the selection of the performance index, the solution of the Riccati equation to obtain the system feedback gain matrix, and the performance obtained from a computer simulation are presented. A conventional amplitude comparison signal processing radar has been fully analyzed, represented mathematically, and computer simulated to compare results between a conventional design and an optimal design using the quadratic performance index. Results obtained show an improvement in pointing and tracking performance for the optimal control design. (Author)

**A81-30302** A millimeter wave radar for U.S. Army helicopters in the 80's. T. R. Holmes and E. A. Flick (E-Systems, Inc., ECI Div., St. Petersburg, Fla.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 2.

New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 712-716. 5 refs. Army-supported research.

In view of the deterioration of optical, laser and infrared weapon guidance systems in inclement weather and battlefield smoke and haze, the synthesis of a state-of-the-art radar system for use by Army helicopters in repelling ground attacks was undertaken. Atmospheric, ground clutter and weather models are simulated and analyzed, and tradeoff studies are performed, to obtain the required operational parameters. Tradeoff studies include operating frequency band, signal format, baseband signal processing techniques, antenna design characteristics, and packaging configuration and display requirements. O.C.

**A81-30303** # Automatic clustering of synthetic aperture radar (SAR) targets. R. L. Withman (USAF, Aeronautical Systems Div., Wright-Patterson AFB, Ohio). In: NAECON 1980; Proceedings

of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 717-724. 12 refs.

Automatic target clustering is discussed as an aid in the exploitation of synthetic aperture radar (SAR) data. Clustering provides a means of detecting concentrations of targets against which limited strike resources can be most effectively deployed. It involves using an automatic change detection process to cluster detected change. Four algorithms are described for the clustering of changes: single linkage, minimal spanning tree (MST), mutual nearest neighbor (MNN), and overlapping pattern cell (OPC). The factors of clustering performance, adaptability, amount of a priori knowledge required, and ease of operator interaction are used to evaluate the algorithms. The OPC algorithm is found to perform best in the two stage variation, and requires the fewest a priori operator inputs of all the algorithms. The MNN algorithm has the disadvantage of being relatively complex compared with the OPC. Overall, the MNN, MST, single linkage, and OPC algorithms perform comparably when the algorithms are optimized. D.K.

**A81-30304** Ground moving target radar signal simulation. J. M. Sandy, III and G. L. Bair, Jr. (Texas Instruments, Inc., Dallas, Tex.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 2.

New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 725-732. 7 refs.

Performance evaluation of airborne radar systems for detection, tracking and identification of ground moving targets can be accomplished effectively using accurately simulated radar signals. This paper describes a simple, yet effective approach for generating these radar signals by computer simulation. The concept incorporates terrain characteristics, target linear and angular motion, target distributed radar cross section, and radar platform motion to generate the target radar signal. The computer simulation provides radar signals that are applicable for analysis of Continuous Wave (CW), and noncoherent and coherent pulse-Doppler radars. The simulated radar signals are useful for analysis of many applications including: (1) design and evaluation of range tracking and Doppler tracking loops, (2) development of target detection algorithms, (3) prediction of radar signal characteristics such as scintillation and target bandwidth, and (4) analysis of target signature characteristics for application to noncooperative target recognition techniques. (Author)

**A81-30310** # Computerized design and optimization of self-contained airborne high power electrical systems. F. C. Brockhurst (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, Ohio). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 2.

New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 768-773.

A fully automated computer-aided design package for self-contained airborne high power electrical systems is studied and a flow chart of the package is given. Implementation of the computerized design process required development of three separate software packages: system feasibility, component design, and system analysis. The present status of each software package is described, outlining the remaining developments needed to implement the design packages. K.S.

**A81-30311** Synergistic benefits of fully integrating JTIDS and GPS. H. J. Rome (Lowell, University, Lowell, Mass.), R. A. Reilly, and C. R. Ward (ITT Corp., ITT Avionics Div., Nutley, N.J.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 2.

New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 780-791. 14 refs.

The key functional design features of a fully integrated JTIDS/GPS receiver are described, and the critical design approach is illustrated by a series of functional block diagrams. It is shown that

by fully integrating the signal processing of both systems and by using appropriate source selection algorithms, dramatic improvements in the positional reliability of both systems can result. A performance estimate underscores the increase in the tolerable jammer-to-signal ratio that this system makes possible. O.C.

**A81-30320 BIT/FIT maturity before first flight.** T. R. McCreary, R. J. Banish, and N. J. Salatino (Boeing Military Airplane Co., Wichita, Kan.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 853-859. USAF-sponsored research.

Presented is a description of the Built-in-Test/Fault Isolation Test (BIT/FIT) mechanization used to achieve failure detection and fault isolation in the B-52 G/H Offensive Avionics System (OAS). OAS is a modification program replacing the 1950's technology equipment with virtually off-the-shelf integrated circuitry. BIT logic is instrumental in achieving 90% fault detection of OAS. BIT/FIT is performed via hardware, firmware, software and the operator. As a result of early testing of the OAS system, the BIT/FIT will reach maturity at the beginning of flight testing. (Author)

**A81-30326 A Single Processor Synchronous Executive derived from the DAIS executive.** S. W. Behnen and R. L. Gutmann (Boeing Military Airplane Co., Seattle, Wash.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 900-906. 5 refs.

This paper provides an overview of the Digital Avionics Information System (DAIS) executive, the rationale for developing a family of executive programs based on the DAIS executive, and a detailed account of the development of the first descendant from the DAIS executive. The DAIS executive program specifications (Part I and II) and the System Control Procedures were the only DAIS documents modified for the new executive; all other documents and standards retain their applicability. The new executive is called the Single Processor Synchronous Executive (SPSE). Any applications task which complies with the SPSE Part I will execute under both the SPSE and the DAIS executive. (Author)

**A81-30327 IFFC fire control system mechanization - Firefly III.** D. W. Meyer, N. Crispino (General Electric Co., Fairfield, Conn.), and B. Lyons (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, Ohio). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1002-1005. Contract No. F33615-78-C-1489.

The architecture of the Firefly III fire control system is described with attention to its relationship with the other elements of the Integrated Fire/Flight Control system. The fire control architecture enables operation of the three basic fire control modes (air-to-air gunnery, air-to-ground gunnery, and bombing) with a full complement of sensors as well as various reduced submodes. The system is mechanized in coupler interface unit software in ten major modules. The system has been designed with a view toward multiple applications and can be used in a number of current aircraft. L.S.

**A81-30328 Integrated Flight/Weapon Control system concepts.** W. J. Murphy (McDonnell Douglas Corp., St. Louis, Mo.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1012-1019. 7 refs. Contract No. F33615-79-C-3604.

The Integrated Flight/Weapon Control (IFWC) program intended to extend earlier systems is discussed. The IFWC program continues the overall technical thrust within the Air Force Flight Dynamics Laboratory to develop integrated flight/fire control

technology, and extends these techniques to increase fighter aircraft weapon delivery capabilities, survivability and operability in the delivery of guided weapons and dispenser munitions. The program is split into two phases. Phase I, recently completed, concentrated on concept development, evaluation and selection using digital analysis methods exclusively. The results of early Phase I concept development and evaluation are summarized, including baseline aircraft and weapons, the Integrated Weapon System, air-to-surface applications, Maverick delivery, Tactical Munitions Dispenser delivery, air-to-air applications, medium range missile applications, and short range missile applications. Phase II involves the continuing development of selected concepts through the preliminary design stage and is still ongoing. D.K.

**A81-30329 Integrated Flight and Weapon Control for improved tactical combat effectiveness.** L. G. Hofmann and H. B. Haake (General Electric Co., Aircraft Equipment Div., Binghamton, N.Y.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1020-1028. Contract No. F33615-79-C-3622.

Integrated Flight and Weapon Control (IFWC) designed to improve tactical air-to-air and air-to-surface combat effectiveness through the integration of flight and fire control is studied. These concepts are applied to enhance survivability in both offensive and defensive roles. The emphasis of IFWC is on automating routine pilot tasks, tasks in periods of inherently high pilot workload and critically timed tasks which require control bandwidth beyond the pilot's capacity. Two air-to-surface IFWC functions are described in detail, self-designation steering for laser-guided bomb delivery and automatic pop-up trajectory. In both these functions, IFWC provides solutions to complex guidance problems involving accelerated paths and inertial cueing, and gives the pilot a degree of operational flexibility to adjust attack conditions at will to the evolving tactical situation without compromising attack effectiveness. The two IFWC modes can also be integrated with IFFC gunnery, bombing and Maverick delivery modes. D.K.

**A81-30330 Stochastic surfaces for flight simulator displays.** R. J. Bethke (Wright State University, Dayton, Ohio). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1030-1033.

The use of linear partial difference equations to generate surface contours and textures for flight simulator displays is demonstrated. By driving these equations with white noise, a wide variety of surfaces or textures can be produced. Generation is done using a digital computer giving flexibility and versatility. Existing surfaces or textures can be modeled giving the required equations for their generation in virtually any amount required. Because the equations allow regeneration of identical surfaces or textures at any time, data storage is reduced to storage of the generating equation. Tuning or modification of the surfaces or textures can be done mathematically with this method as opposed to physical modification of a scale model, photographic or other methods. By modifying the equations during the generation process, it is possible to generate surfaces or textures with perspective such that they have 3-dimensional information. (Author)

**A81-30331 # Simulation techniques for new generation aircraft maintenance training devices.** C. E. Patterson (USAF, Aeronautical Systems Div., Wright-Patterson AFB, Ohio). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1034, 1035.

The shift in the approach to aircraft technician maintenance training from hardware to software technology is examined. The focus for software training is on the F-16 Simulated Aircraft

Maintenance Trainer (SAMT), an intensive trainer using mathematical algorithms to simulate the functions of selected aircraft systems. The hardware for each SAMT consists of a commercially available minicomputer system and a system peculiar Simulation Panel Set (SPS), which graphically depicts the aircraft systems and their relative location within the aircraft. All the software necessary to operate each SAMT is contained in three Computer Program Configuration Items (CPCIs), the operational software CPI, the Test and diagnostic software CPI, and the support software CPI. Although the SAMT program has suffered cost and schedule overruns, it can still help cut aircraft equipment costs without sacrificing training value. D.K.

**A81-30332 # Integration of the F-16 Weapon System Trainer.** J. F. Lethert (USAF, Aeronautical Systems Div., Wright-Patterson AFB, Ohio). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1036-1038.

The paper describes the integration of several systems that make up the F-16 Weapons Systems Trainer. Each system is purchased on a separate contract. The paper discusses the principles used to integrate the systems and the application of the principles to computer hardware and computer software. (Author)

**A81-30334 Information requirements for airborne electronic terrain maps.** G. G. Kuperman (USAF, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio), A. J. DeFrances (Systems Research Laboratories, Inc., Dayton, Ohio), and D. L. Sander (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, Ohio). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1046-1051. 9 refs.

The Airborne Electronic Terrain Map System (AETMS) is presented as an alternative to current cartographic information displays. Contemporary map displays are reviewed, and changing requirements (e.g., low altitude, high-speed profiles) are indicated. Because of its programmable format selection, the AETMS affords the aircrew member either downward- or forward-looking perspective displays of terrain relief information. This permits optimizing the transfer of cartographic data. The AETMS is a computer-generated display, and offers a simple and direct approach to integrating JTIDS and other external information sources. Correlation of terrain relief information and onboard passive sensor information is facilitated due to its realistic perspective display capability. The capability to perform inflight route review may be of particular importance in selecting weapon delivery tactics. K.S.

**A81-30335 Tailoring software logic to the needs of the pilot - A software designer's nightmare.** J. Murray (System Consultants, Inc., Dayton, Ohio) and J. Reising (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, Ohio). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1052-1056. 5 refs.

Digital avionics and multifunction displays and controls are being incorporated into aircraft of the Air Force, Navy and Army with increasingly greater frequency. One of the key aspects in their acceptance and usefulness is the design of the software so that it supports the needs of the user, specifically, the pilot. By tailoring the software such that display formats and multifunction control logic are custom-designed to appropriate mission phases, a reduction in pilot workload is accomplished. A series of studies have been conducted examining this reduction in pilot workload by employing Tailored Multifunction Control Logic versus standard Branching Control Logic. A significant improvement in pilot performance has resulted from the use of Tailored Logic. However, in an era of ever increasing software costs, the benefits to the pilot need to be

weighed against the costs of implementing this tailored software.

(Author)

**A81-30336 # DAIS controls and displays - A systems approach to avionics subsystem integration.** G. W. Brown and J. D. Garcher (USAF, Avionics Laboratory, Wright-Patterson AFB, Ohio). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1057-1064. 5 refs.

The increasing complexity of U.S. Air Force aircraft mission requirements and the necessity for reducing avionics life cycle costs require a total systems approach to future avionics subsystem integration. The Digital Avionics Information System Controls and Displays (C/D) is an integrated subsystem that utilizes specific pilot control procedures and common communication techniques to accomplish virtually all avionics functions with the same pilot C/D hardware. This paper discusses the system design approach needed during avionics development process to achieve an integrated C/D subsystem. Emphasis is placed on interaction between pilot procedures, mission operations, and C/D subsystem and related interfaces. The reconfiguration capabilities, the ease of incorporating new avionics functions and other benefits derived from common C/D hardware are also addressed. Finally, critical issues facing C/D such as pilot workload, acceptance by the avionics community of new control and display techniques, degree of display device complexity and C/D areas amenable to standardization are examined. (Author)

**A81-30337 # KC-135 modernization program.** C. Sweet and G. Morris (USAF, Aeronautical Systems Div., Wright-Patterson AFB, Ohio). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1065-1081.

A request to study the feasibility of eliminating the navigator as a member of the KC-135 aircrew will result in a crew station evaluation by the Flight Dynamics Laboratory of the Air Force Wright Aeronautical Laboratories, a dynamic simulation of selected subsystems by Aeronautical Systems Division, and a hot bench mockup by the Avionics Update Study. The primary avionics subsystems approach taken involves reducing the navigation workload and redistributing tasks among the pilot and co-pilot. In addition, the latter's workload will be reduced to enable the crew to absorb the extra loading. This will require the total integration of the cockpit avionics subsystems (i.e., navigation, fuel management, flight management, etc.) whereby a central computer will be used as the means of reducing the workload by using techniques of automation and control simplicity. This integration will be accomplished by use of a MIL-STD-1553B Multiplex Data Bus and MIL-STD-1750 computer and involves installation of displays and data entry display keyboards for the pilot and co-pilot. (Author)

**A81-30338 Integrated displays and controls design factors for the 1990's transport aircraft.** M. D. Prince (Lockheed-Georgia Co., Electronics Div., Marietta, Ga.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1082-1089. 18 refs.

Integrated displays and controls that will be required in the 1990's transport aircraft to cope with added workload caused by more congested airspace, added systems functions, and smaller crew sizes are discussed. Four factors influencing flight station design are examined. The first factor is the mission and its environment. The second is the systems environment which includes external systems, on-board systems, monitoring and alerting functions and numerous subsystems. The third factor is the availability of technology which includes developments such as color CRT's, flat panel displays, multifunction switches and panels, multiplex data buses, distributed computing and speech processing. The fourth factor is human characteristics which include psychophysical factors, cognitive fac-

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tors, work load and stress levels, and skill and alertness maintenance. Relevant military, NASA and industry programs in displays and controls are reviewed. One version of an advanced flight station is presented and some of its display and control features are discussed.

D.K.

**A81-30339** The reconstruction/refiltering approach to Kalman filter evaluation. F. J. Cook and J. E. Bergeson (Boeing Military Airplane Co., Seattle, Wash.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1092-1099.

An approach to flight test evaluation of aided-inertial systems is presented using a reconstruction/refiltering concept. The technique utilizes computer program processing of recorded flight test data. The program removes the effects of filter-derived corrections and evaluates the performance impact of filter design changes without additional flights. Examples of program output are given in the context of results from a B-1 test flight.

L.S.

**A81-30340** Implementation of target orientation angles in improved Kalman filter based short range radar tracking. J. N. Hoffner and D. W. Baggett (Hughes Aircraft Co., Los Angeles, Calif.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1100-1106.

Present day airborne radars can effectively track target position in the highly dynamic short range environment (below 2 nmi). However, accurate target velocity and acceleration estimates, which are required for an effective fire control solution, often lag the actual target states in a high-gravity air combat situation. This lag limits the performance of not only guns but also short range missiles and high energy lasers. A combined electro-optical (E-O) sensor radar tracking approach to reducing the lags, called META (Motion Estimation using Target Aspect), has been developed and evaluated. The method of moments is used to determine the roll, pitch and yaw of the target relative to the E-O sensor boresight. By appropriate transformation and filtering, based on target attitude, coupled with aircraft motion assumptions, accurate estimates of target acceleration can be derived. This improved estimate is then used to aid an angle track Kalman filter to provide improved state estimation capability.

(Author)

**A81-30341** Producibility engineering at ASD. S. P. Mediratta and J. F. Dreher (USAF, Aeronautical Systems Div., Wright-Patterson AFB, Ohio). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1116-1123.

Producibility engineering is receiving increased attention at ASD. Producibility engineers, acting as interface between design and manufacturing engineers, aspire to achieve optimum in design for producibility considerations. To maximize the benefits from producibility tradeoffs, ASD emphasizes that the efforts of design and manufacturing engineers must be integrated early in the system acquisition phase. This is accomplished by imposing various producibility requirements in contracts. Requirements vary depending upon the type and phase of the program. Several sample producibility requirements are presented, followed by recent examples of savings realized through an organized producibility effort.

(Author)

**A81-30343** Heat pipe avionic cooling. K. H. Token and R. S. Cook (McDonnell Aircraft Co., St. Louis, Mo.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3.

New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1136-1143. 6 refs.

This paper evaluates thermal designs using heat pipes and liquid coolants, for cooling leadless chip carrier components. The evaluation is relative to direct air impingement thermal designs, within the

constraints of the Navy's Modular Avionic Packaging Concept. Both rack and individual avionic unit enclosures are considered. Coolant supply requirements, to provide equal avionic reliability, are determined for both thermal designs. Environmental Control Systems (ECS) are sized to provide the coolants. The impact of each thermal design on aircraft takeoff-gross-weight due to avionics and the ECS is evaluated for a subsonic V/STOL aircraft. Heat pipe thermal designs are shown to result in smaller and lighter avionic enclosures and to require less demanding coolant supply conditions compared to direct air impingement thermal designs. Heat pipe avionic thermal designs result in significantly lower aircraft take-off gross weight and better avionic reliability. Prototype avionic heat pipe developments are briefly described.

(Author)

**A81-30347** Cybernetic airborne fire control - Issues and potential. J. M. Nash and M. M. Dresser (VERAC, Inc., San Diego, Calif.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1170-1177. 16 refs. Contract No. F33615-79-C-1939.

Issues relating to the computerization of defensive response to threats posed by enemy aircraft and missiles to strategic or tactical aircraft are addressed. Problems inherent in the coordination of decision-making and fire control are stressed, and the role that may be played by foreseeable advances in computer hardware and software and electronic sensors is considered. It is concluded that because of the sharp escalation of computational operations that follows from increases in the number of targets being considered, real-time optimal response cannot be implemented in the near future. Attention is given the possibility of dividing fire control authority between human and computer elements of a system in order to capitalize on the unique capabilities of each.

O.C.

**A81-30348 #** Fighter fire control requirements for air battles of the future. R. A. Manske and A. A. Duke, Jr. (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, Ohio). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1178-1180.

This paper discusses and lists the fire control system requirements for fighter aircraft (with airframes typified by the F-15 and F-16) in a multiple target air threat environment in the post-1985 period. The expected weapons of most interest are the Advanced Medium Air-to-Air Missile (AMRAAM), and the AIM-9 (Sidewinder) and AIM-7 (Sparrow) missiles in their present and improved forms. Comparison of present-day requirements with those listed indicates a number of areas for improvement. The introduction of a missile such as the AMRAAM will make some changes mandatory. Integration techniques and computational algorithms for an integrated approach to fire control need further development. Some of the requirements are: tracking of multiple targets, identification of targets, missile launching computation and battle management functions.

K.S.

**A81-30349** Multisensor track file correlation using attributes and kinematics. C. L. Bowman (VERAC, Inc., San Diego, Calif.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1181-1186. 12 refs.

A general multisensor, multitarget track correlation sequential architecture is defined, and multisensor integration objective criteria are presented. An evaluation of the criteria based on sensor target kinematics and attributes reports and a priori sensor properties is conducted. A candidate algorithm based on each sensor providing the best estimate of the target kinematics and classification is described for an avionics application.

L.S.

**A81-30352 #** Effects of sunlight on display filters. K. E. Yarger and H. L. Waruszewski (USAF, Aeronautical Systems Div.,

Wright-Patterson AFB, Ohio). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1216-1218.

The F-4G advanced Wild Weasel aircraft at George AFB, California, began experiencing a degradation of the displays and controls CRT contrast enhancement filters. The degradation is a loss of contrast ratio as a result of the contrast filter discoloring when exposed to sunlight. An inquiry revealed that the F-15 was also experiencing the same type of problem. An initial investigation revealed that the ultraviolet component of direct sunlight was the primary culprit. ASD is undertaking an evaluation of the effects of sunlight on contrast filters produced by several manufacturers. This evaluation is to determine if a better contrast filter is available and to possibly establish a test method/criteria to qualify contrast filters in order to prevent recurrence of the problem described above. This presentation details the problems already uncovered, the procedures and techniques that will be used in the evaluation, and preliminary test results. (Author)

**A81-30353 F/A-18 horizontal situation display.** P. R. Snow (McDonnell Douglas Corp., St. Louis, Mo.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1219-1226.

The F/A-18 Hornet strike/fighter scheduled for fleet introduction in 1982 will contain a horizontal situation display (HSD) which combines a full color moving map display with cathode ray tube (CRT) overlays as the primary navigation display. The full color moving map function is provided by optical projection of standard navigation chart information recorded on 35mm color film. This map image is optically combined with the CRT imagery by a beamsplitter and the combined image projected and formed into a virtual image at the HSD front face. This paper discusses background information on HSD's, types of HSD implementation, HSD System integration, and its uses and capabilities in the Hornet. (Author)

**A81-30354 B-52 Offensive Avionics System (OAS) control and display design, using a Dynamic Mockup.** G. L. Seveck (Boeing Military Airplane Co., Wichita, Kan.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1227-1235. Contract No. F33657-78-C-0500.

The B-52 Offensive Avionics System (OAS) Dynamic Mockup (DMU) allows the performance of design simulation studies in order to optimize design. Among the objectives of this approach are flight safety, crew workload reduction and reliability. Performing such tests on the DMU may obviate their scheduling during test flights for validation, permitting limited and expensive flying hours to be devoted to tests in which aircraft operation is essential. O.C.

**A81-30355 F/A-18 Hornet Crew Station.** E. C. Adam (McDonnell Aircraft Co., St. Louis, Mo.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1236-1240.

While the F/A-18 cockpit has 40% less usable area than comparable aircraft but still requiring that both fighter and attack roles be managed by a lone pilot, extensive integration of its weapon system controls and displays is necessary. The rationale for the resulting cockpit configuration of four multipurpose CRT displays driven by two mission computers, and its generation and validation by a process of combined analysis and simulation, are discussed. The system also features an integrated up-front control panel and numerous 'stick and throttle' automatic functions. O.C.

**A81-30356 Logistics support of avionic software stored on erasable programmable read only memory.** D. B. Day. In: NAECON

1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3.

New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1252-1257.

Several approaches to the modification of software stored on erasable programmable read-only memory (EPROM) are examined, including the depot level of avionics maintenance and the intermediate shop level of maintenance. Analysis indicates that the most cost effective approach is to develop a stand alone EPROM reprogrammer for both the intermediate and depot levels of maintenance. V.L.

**A81-30358 The RLU - An advanced remote terminal for avionic systems.** C. J. Tavora and J. R. Glover, Jr. (Houston, University, Houston, Tex.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1271-1278. 6 refs. Contract No. F33615-78-C-1634.

This paper describes the design of the Remote Link Unit (RLU) at a functional level. The RLU is an intelligent remote terminal which is compatible with hierarchical distributed processing. It has interface modules capable of processing subsystem data on-the-fly and supporting a universal signal interface which can be configured under software control to input or output analog and digital signals of varied types. Electronic nameplates containing identification, interface requirements and signal processing programs are attached to avionics subsystems to support the RLU operational features. The RLU stand-alone processing capabilities facilitate maintenance and provide fault tolerance. The RLU is being evaluated by the Air Force for use in the Digital Avionics Information System (DAIS). (Author)

**A81-30359 Integrated flight and fire control development and demonstration of an F-15B aircraft.** R. J. Landy (McDonnell Aircraft Co., St. Louis, Mo.). In: NAECON 1980; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 20-22, 1980. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1980, p. 1283-1295. USAF-sponsored research.

The Integrated Flight and Fire Control (IFFC) program is a USAF Advanced Development Program to design, build, test, and evaluate an automatic coupler and modified flight control system to steer out tracking errors calculated by a director fire control system using information from an ATLIS II electro-optical tracker. The F-15B aircraft is the test bed aircraft. Simulation and analysis results indicate that the IFFC system has excellent air-to-air gunnery accuracy with decreased pilot workload. These results also indicate that attacker survivability in air-to-ground gunnery and bombing encounters can be increased by using maneuvering approaches. Accuracies during these IFFC maneuvering deliveries are at least as good as those achieved manually using conventional delivery approaches. These conclusions were to be further evaluated in a 15 month flight test program to begin in late 1980. (Author)



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## STAR ENTRIES

**N81-20008#** Technische Universitaet, Munich (West Germany).  
Lehrstuhl fuer Flugmechanik und Flugreglung.

### FLIGHT DATA RECORDING AND DATA PROCESSING FOR LIGHT AIRPLANES AND GLIDERS

J. W. Siefert /in DFVLR On Contrib. to 10th Symp. on Aircraft Integrated Data Systems Jun. 1980 p 9-33 In GERMAN; ENGLISH summary

Avail: NTIS HC A16/MF A01

A flight data recording and processing system is described, emphasizing the importance of the proper selection of transducers. The processing system includes modular processing programs for the time histories of the flight mechanical state and control variables as well as their subsequent processing. Programs for the three dimensional presentation of flight paths and for flight performance graphs are also applied to this data structure. For the evaluation of flight tests, a simulation program was developed. With this system pre and post simulations can be performed. Results of performance, stability, and control measurements are shown. Author (ESA)

**N81-20013#** Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).

### INDIVIDUAL JET ENGINE STRESS LOAD MONITORING WITH THE AID OF THE FLIGHT DATA RECORDING SYSTEM LEADS 200

J. Knittel and B. Mueller /in DFVLR On Contrib. to 10th Symp. on Aircraft Integrated Data Systems Jun. 1980 p 135-151 In GERMAN; ENGLISH summary

Avail: NTIS HC A16/MF A01

A long term counting of stress cycles for a J 79-J1 K engine of a F-104 G was performed using the flight data recording system LEADS 200. Comparison of number of accumulated cycles as a function of engine running time shows remarkable differences between individual engines at a fixed engine run time, i.e., at engine overhaul interval, due to the different operation of each aircraft. Results indicate that at least a partial on-condition maintenance program depending on engine stress counting promises a realistic cost saving for combat aircraft. Author (ESA)

**N81-20014#** Technische Hochschule, Aachen (West Germany).  
Inst. fuer Strahlantriebe und Turbomaschinen.

### IDENTIFICATION OF JET ENGINE DAMAGES BY ENGINE TREND ANALYSIS LEADS 200 DATA

W. Koschel /in DFVLR On Contrib. to 10th Symp. on Aircraft Integrated Data Systems Jun. 1980 p 153-181 refs In GERMAN; ENGLISH summary

Avail: NTIS HC A16/MF A01

The flight data recording system LEADS 200 is used for maintenance support and trouble shooting of military aircraft. A main part of the monitoring system LEADS 200 consists of the engine parameter trend analysis. By this the long term behavior of the engine can be observed. It can also be used for the identification of damage. Given the component characteristics as a basis it is possible to predetermine the effects of damage on the engine operation and on the deviation of engine trend parameters. Some examples of jet engine damage and identification by engine trend analysis are discussed. Author (ESA)

**N81-20015#** Technische Hochschule, Aachen (West Germany).  
Lehrstuhl fuer Strahlantriebe und Turbomaschinen.

### SOME EFFECTS OF COMPRESSOR FOULING ON THE

### BEHAVIOR OF A TURBOJET ENGINE

H. Toenskoetter /in DFVLR On Contrib. to 10th Symp. on Aircraft Integrated Data Systems Jun. 1980 p 183-218 refs In GERMAN; ENGLISH summary

Avail: NTIS HC A16/MF A01

Difficulties in the identification of compressor faults by an engine condition monitoring system are discussed. For the example of compressor fouling, simulated on a single spool turbojet engine with a seven stage axial flow compressor, the effects on compressor characteristics (mass flow, pressure ratio, and efficiency) and on additional parameters that are significant for engine condition monitoring are presented. The influence on the behavior of the compressor stages and on the surge line is described. Experimental results are compared with calculated parameter changes showing satisfactory agreement for compressor fouling. Cleaning and surge line determination methods are shown. Author (ESA)

**N81-20016#** British Airways, Middlesex (England).

### USES OF AIDS DATA IN AIRLINES ENGINE MAINTENANCE

E. R. White /in DFVLR On Contrib. to 10th Symp. on Aircraft Integrated Data Systems Jun. 1980 p 219-234

Avail: NTIS HC A16/MF A01

The use of aircraft integrated data systems (AIDS) for assisting in engine maintenance scheduling is discussed. Four examples are cited: (1) determination of the failure rate for the engine starter on the trident; (2) analysis of excessive turbine gas temperature on takeoff for particular engines; (3) investigation of Boeing 747 deceleration surging; and (4) Tri-Star and Boeing 747 N2 monitoring. Each problem is detailed and AIDS data pertinence is shown. Author (ESA)

**N81-20018#** Eurocontrol Agency, Brussels (Belgium).

### POSSIBLE ONLINE USES OF AIDS DATA IN FUTURE ATC SYSTEMS

M. E. Cox /in DFVLR On Contrib. to 10th Symp. on Aircraft Integrated Data Systems Jun. 1980 p 263-291 refs

Avail: NTIS HC A16/MF A01

The feasibility of exploiting aircraft integrated data systems (AIDS) data in real time or near real time for air traffic control (ATC) related purposes is discussed. How the transfer of data can be carried out by a two way air/ground digital data link and the interface to accept AIDS data outputs are described. Possible ATC applications for AIDS data include meteorological forecasting, radar tracking, and maneuver detection. Probable future requirements for onboard AIDS are considered for civil and military aircraft. Some preliminary results obtained with an experimental AIDS data link transponder interface onboard Tristars are reported. Author (ESA)

**N81-20019#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugmechanik.

### EXPERIENCES WITH FLIGHT RECORDERS OBTAINED BY ANALYZING AIRCRAFT ACCIDENTS

O. Weber and G. Rosenau /in its On Contrib. to 10th Symp. on Aircraft Integrated Data Systems Jun. 1980 p 293-321 refs In GERMAN; ENGLISH summary

Avail: NTIS HC A16/MF A01

The readings of old fashioned flight recorders after a takeoff accident in Africa and two midair collisions within German airspace were analyzed. The possibilities and limitations of the recorded data were treated in detail with regard to the reconstruction of the sequence of events and the performance of the aircraft. Flight data determined by means of a digital flight recorder during takeoff and climb of a three engine jet were similarly analyzed in order to verify whether better results can be obtained by using more advanced integrated data systems. The superiority of the digital technique is shown. Author (ESA)

**N81-20020#** National Transportation Safety Board, Washington, D. C. Bureau of Technology.

**A TECHNIQUE FOR RECOVERING NONSYNCHRONIZED DATA FROM A DIGITAL FLIGHT DATA RECORDER**

Carol A. Roberts /In DFVLR On Contrib. to 10th Symp. on Aircraft Integrated Data Systems Jun. 1980 p 323-351 refs

Avail: NTIS HC A16/MF A01

How critical data in out-of-synch areas of a digital flight data recorder tape can be recovered using a serial binary technique called BITDUMP is explained. Digital flight data recorder data recovery depends on the acquisition of a synchronization word once every second. Critical synchronization timing is interrupted if tape motion becomes unsteady or if the tape breaks on impact in an aircraft accident. Several cases where synchronization of critical data was lost because of tape breakage, as in the American Airlines DC-10 accident at Chicago, Illinois, on May 25, 1979 and the Air New Zealand DC-10 accident in Antarctica on 28 November 1979 are cited. The American Airlines DC-10 accident is analyzed in detail to demonstrate BITDUMP application. Author (ESA)

**N81-20021#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugfuehrung.

**A QUICK-LOOK SYSTEM FOR THE PROCESSING OF FLIGHT DATA RECORDINGS**

G.-J. Barth /In its On Contrib. to 10th Symp. on Aircraft Integrated Data Systems Jun. 1980 p 353-371 refs In GERMAN; ENGLISH summary

Avail: NTIS HC A16/MF A01

A data reduction system which facilitates the routine inspection of digital flight recorder data is described. A PCM bit synchronizer detects and regenerates magnetic tape signals, the pulses of which are strongly distorted. The device outputs NRZ data and a phase adapted clock signal. A connected frame synchronizer is able to process alternating synchwords and locks to the beginning of the frame sequence. In connection with a desk top computer, eight different flight data channels can be decommutated, recorded on a strip chart recorder, and displayed as bargraphs on the computer integrated TV screen. A 12 bit parallel TTL compatible interface to a computer allows for user implemented analysis. Author (ESA)

**N81-20025\*#** National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

**AERODYNAMIC CHARACTERISTICS OF A HYPERSONIC CRUISE AIRCRAFT CONCEPT WITH WING-MOUNTED PROPUSSION SYSTEMS AT MACH NUMBERS OF 2.96, 3.96 AND 4.63**

Gregory D. Riebe and Jimmy L. Pittman Mar. 1981 50 p refs

(NASA-TM-81937; L-14168) Avail: NTIS HC A03/MF A01 CSCL 01A

Longitudinal aerodynamic data are presented for a Mach 6 transport concept at Mach numbers of 2.96, 3.96, and 4.63. The model components consisted of a lenticular cross section fuselage, a wedge slab wedge wing, a horizontal tail set, a wedge center vertical tail, a set of flow through ramjet nacelles mounted under the wing, and a set of turbojet nacelles simulated by solid bodies mounted on the upper surface of the wing. Estimates from hypersonic impact theory were compared with experimental data for several of the test configurations. The method, which applied tangent cone empirical theory to the body and tangent wedge theory to the planar surfaces, generally provided a good estimate of the fuselage wing tail data. Comparisons, however, for the configuration buildup showed that the theoretical estimates for the various components could be significantly different from the experimental data, which is an indication of errors in the local pressure estimates. Author

**N81-20026\*#** National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

**A COMPUTER TECHNIQUE FOR DETAILED ANALYSIS OF MISSION RADIUS AND MANEUVERABILITY CHARACTERISTICS OF FIGHTER AIRCRAFT**

Willard E. Foss, Jr. Mar. 1981 67 p  
(NASA-TP-1837; L-14213) Avail: NTIS HC A04/MF A01 CSCL 01A

A computer technique to determine the mission radius and maneuverability characteristics of combat aircraft was developed. The technique was used to determine critical operational requirements and the areas in which research programs would be expected to yield the most beneficial results. In turn, the results of research efforts were evaluated in terms of aircraft performance on selected mission segments and for complete mission profiles. Extensive use of the technique in evaluation studies indicates that the calculated performance is essentially the same as that obtained by the proprietary programs in use throughout the aircraft industry. E.D.K.

**N81-20027\*#** Boeing Vertol Co., Philadelphia, Pa.  
**TOTAL MAIN ROTOR ISOLATION SYSTEM ANALYSIS**

V. Sankewitsch Hampton, Va. NASA, Langley Research Center Mar. 1981 82 p refs

(Contract NAS1-16176)  
(NASA-CR-165666; D-210-11788-1) Avail: NTIS HC A05/MF A01 CSCL 01A

Requirements, preliminary design, and verification procedures for a total main rotor isolation system at n/rev are presented. The fuselage is isolated from the vibration inducing main rotor at one frequency in all degrees of freedom by four antiresonant isolation units. Effects of parametric variations on isolation system performance are evaluated. E.A.K.

**N81-20028\*#** Barna (P. Stephen), Consultant, Norfolk, Va.  
**EXPERIMENTAL INVESTIGATIONS ON THE V/STOL TUNNEL AT NASA/LANGLEY RESEARCH CENTER**

P. Stephen Barna Feb. 1981 78 p refs

(NASA Order L-12343B)  
(NASA-CR-165655) Avail: NTIS HC A05/MF A01 CSCL 01A

The flow characteristics of the V/STOL tunnel were investigated. The results show an interaction between tunnel components. The flow around the tunnel circuit gradually deteriorated with increasing distance from the testing area. The flow in the first diffuser was still satisfactory at the beginning of the circuit, while at the end of the circuit, the flow approaching the contraction became entirely unsatisfactory. Deterioration of flow was due largely to turning the stream around the corners, with the resulting flow distortion affecting the diffusers downstream. The large end of the last diffuser stalled on one side and nearly stalled the flow at the tip of the fan. It was found that these adverse flow characteristics reduce the flow quality and the efficiency of the tunnel. E.A.K.

**N81-20029\*#** National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

**THE PHENOMENON OF DYNAMIC STALL**

W. J. McCroskey Mar. 1981 33 p refs Prepared in cooperation with Army Research and Technology Labs., Moffett Field, Calif. (NASA-TM-81264; A-8464) Avail: NTIS HC A03/MF A01 CSCL 01A

The general features of dynamic stall on oscillating airfoils are explained in terms of the vortex shedding phenomenon, and the important differences between static stall, light dynamic stall, and deep stall are described. An overview of experimentation and prediction techniques is given. M.G.

**N81-20030\*#** National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

**AN EXTENSION OF THE LOCAL MOMENTUM THEORY TO A DISTORTED WAKE MODEL OF A HOVERING ROTOR**

Keiji Kawachi Feb. 1981 112 p refs  
(NASA-TM-81258; A-8436) Avail: NTIS HC A06/MF A01 CSCL 01A

The local momentum theory is based on the instantaneous balance between the fluid momentum and the blade elemental lift at a local station in the rotor rotational plane. Therefore, the theory has the capability of evaluating time wise variations of air loading and induced velocity distributions along a helicopter blade span. Unlike a complex vortex theory, this theory was developed to analyze the instantaneous induced velocity distribu-

tion effectively. The boundaries of this theory and a computer program using this theory are discussed. A concept introduced into the theory is the effect of the rotor wake contraction in hovering flight. A comparison of this extended local momentum theory with a prescribed wake vortex theory is also presented. The results indicate that the extended local momentum theory has the capability of achieving a level of accuracy similar to that of the prescribed wake vortex theory over wide range variations of rotor geometrical parameters. It is also shown that the analytical results obtained using either theory are in reasonable agreement with experimental data. E.D.K.

**N81-20031\*** National Aeronautics and Space Administration, Washington, D. C.

**THE ELABORATION OF A NEW FAMILY OF HELICOPTER BLADE PROFILES**

J. J. Thibert Jan. 1981 15 p refs Transl. into ENGLISH from L'Aeron. et l'Astron., (France), no. 81, Feb. 1981 p 13-19 Original language document announced as A80-48126 Transl. by Kanner (Leo) Associates, Redwood City, Calif. Original doc. prep. by ONERA (Contract NASw-3199) (NASA-TM-75907) Avail: NTIS HC A02/MF A01 CSCL 01C

An airfoil family of helicopter rotor blades was designed. Three airfoils with thickness to chord ratios of 12, 9, and 7% were designed. Their improved performance in two dimensional rotor mockup wind tunnel tests led to testing of the tapered blades on four bladed rotors in a wind tunnel and flight tests on the Dauphin series of helicopters, confirming the expected gains. J.D.H.

**N81-20034#** New Jersey Inst. of Tech., Newark  
**SIMULATION OF AEROHEATING OR AEROCOOLING AIR FORCE STORES BY ARRAYS OF IMPINGING JETS** Final Report, Sep. 1979 - Jul. 1980

Peter Hrycak Oct. 1980 59 p refs  
(Contract F33615-79-C-3417; AF Proj. 2402)  
(AD-A095464; AFWAL-TR-80-3105) Avail: NTIS HC A04/MF A01 CSCL 20/13

The New Jersey Institute of Technology conducted a conceptual study using existing analytical and experimental data to assess the feasibility of using impinging air jets to heat and cool a large structure such as a store. It was found to be feasible to use impinging jets; however, a prediction of the total mass flow of air required was difficult to accomplish because of the lack of data concerning the efficiencies of arrays of impinging jets. GRA

**N81-20038#** National Aerospace Lab., Amsterdam (Netherlands). Flight Dynamics Div.

**UNSTEADY AIRLOADS ON A HARMONICALLY PITCHING WING WITH EXTERNAL STORE**

R. Roos 31 Jan. 1980 10 p refs Presented at AIAA/ASME 21st Struct., Structural Dyn. and Mater. Conf., Seattle, 12-14 May 1980 Co-sponsored by AFFDL (Grant AF-AFOSR-3233-77) (NLR-MP-80004-U) Avail: NTIS HC A02/MF A01

Wind tunnel tests were carried out on a harmonically pitching fighter-type wing with and without an air to air missile. Steady and unsteady pressure distributions were measured on the wing, while the aerodynamic loads on the store were also obtained. The Mach number ranged from 0.6 to 1.35, while frequencies up to 40 Hz ( $k = 0.4$ ) were achieved. The influence of the store on the unsteady wing loading, behavior of the unsteady store loads, and comparison with unsteady calculations are examined. It is shown that for transonic conditions the interference due to the tipstore as well as the pylon store spreads over the full wing, while at supersonic speeds the influence remains localized within the Mach cone. The normal load and side load experienced by the store become consistently larger as the complexity of the store increases, while for the pitching moment the contribution of the canard fins is very important. For subsonic flow conditions it is shown that in a matching process with a more expensive panel method. It is possible to define a panel distribution of a doublet lattice calculation which properly accounts

for the interference effects due to a store and the store loads themselves. Author (ESA)

**N81-20039#** National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.

**A PANEL METHOD TO DETERMINE LOADS ON OSCILLATING AIRFOILS IN TRANSONIC FLOW WITH EMBEDDED SHOCK WAVES**

M. H. L. Hounjet 7 Mar. 1980 10 p refs Presented at AIAA/ASME 21st Struct., Structural Dyn. and Mater. Conf., Seattle, 12-14 May, 1980 Sponsored by Research Branch of Directorate of Materiel (NLR-MP-80005-U) Avail: NTIS HC A02/MF A01

A two dimensional panel method which combines supersonic and subsonic linear lifting surface theories is based on the velocity potential panel approach and accounts for the effect of the moving shock. A simplified representation of a mean steady symmetric flow field which is divided into a supersonic constant Mach number region separated by a straight normal shock is used. For a NACA 64A006 airfoil, transonic results are presented and compared with results of an improved version of the LTRAN2 code. A 95% saving in computer run time is realized.

Author (ESA)

**N81-20040#** Royal Aircraft Establishment, Farnborough (England).

**LEADING-EDGE SEPARATION FROM A SLENDER ROLLING WING-BODY COMBINATION**

I. P. Jones (Atomic Energy Research Establishment) London HMSO Mar. 1980 72 p refs Sponsored by Univ. of East Anglia, England and UK Ministry of Defence (RAE-TR-80039; RAE-Aero-3476; BR74711) Avail: NTIS HC A04/MF A01

A vortex-sheet model of leading-edge separation was used to study the flow about a slender wing-body combination in steady rolling motion at zero incidence. The equations which model the flow were derived. For a numerical solution of the equations, the representation of the vortex sheet in the cross flow plane was discretized, so that the unknowns become a finite set of coordinates and strengths, and the boundary conditions become a finite set of ordinary differential equations. The streamwise derivatives which occur in these equations are represented by central differences in an implicit formulation.

Author (ESA)

**N81-20043#** Bristol Univ. (England). Dept. of Aeronautical Engineering.

**AN INVESTIGATION OF DRAG ASSOCIATED WITH THE UPSWEPT REAR FUSELAGE OF A HELICOPTER B.S. Thesis**

H. Mistry and R. Lamb Jun. 1980 52 p refs (BU-257) Avail: NTIS HC A04/MF A01

The effect of flow changes around the rear fuselage of typical helicopter configurations was studied using a one-fifth scale Westland Lynx model. Modifications were added to the rear fuselage in order to vary its geometry. The model was wind tunnel tested at a Reynolds number (based on the length of the fuselage body) of 3.5 million. Two basic fuselage configurations were tested, one with a parallel sided rear fuselage, the other with taper. The effect of upsweep angle and the incidence of the model on lift, drag, and pitching moment was studied. Pressure readings were taken on the rear upswept face and a series of flow visualization tests was also done. Dramatic changes in the flow pattern were found on the parallel sided fuselage configuration. A definite correlation between the pressure changes on the upswept surface associated with the changing flow pattern there and the sudden drag change was confirmed. It was found that rear fuselage taper effectively killed off the critical flow changes although the same types of flow were still present.

Author (ESA)

**N81-20044\*** National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

**A PILOT TRAINING MANUAL FOR THE TERMINAL CONFIGURED VEHICLE ELECTRONIC HORIZONTAL SITUATION INDICATOR**

Jacob A. Houck Mar. 1981 64 p refs

(NASA-TM-81959) Avail: NTIS HC A04/MF A01 CSCL 05I

The initial phase of a training program for the Terminal Configured Vehicle Electronic Situation indicator (EHSI) is presented. The EHSI and its symbology is introduced and interpretation of the symbols is explained. Basic symbols shown on the display at all times are first presented. Additional optional symbols to be used as appropriate during different portions of a flight are then introduced and various display configurations interpreted. The upper half of each page is a reproduction of the EHSI display or other pertinent instructional material and the bottom half contains explanatory text, simplifying production of an audiovisual package for use with large training classes. Two quizzes on the course material are included. J.D.H.

**N81-20045#** Parker (Lee W.), Inc., Concord, Mass.

**AIRBORNE LIGHTNING WARNING SYSTEMS: A SURVEY Final Report, Aug. 1979 - Jun. 1980**

Lee W. Parker and Heinz W. Kasemir Jul. 1980 108 p refs (Contract F19628-79-C-0161)

(AD-A095354; AFGL-TR-80-0226) Avail: NTIS HC A06/MF A01 CSCL 01/2

Lightning warning systems for airborne use may be classified in accordance with their application as near-zone warning systems, and distant warning systems. The near-zone systems considered here are essentially electrostatic field detectors (field mill, radioactive probe, and corona point) that can warn of the presence not only of thunderstorms but of high electric fields associated with nonthunder clouds that may nevertheless cause triggered strikes to aircraft (far outnumbering strikes due to natural lightning, according to pilot reports). Lightning-strike and high-field statistics, and associated corona effects, are discussed in connection with triggering of strikes. The distant warning systems considered, aside from airborne weather radar, include RF electric and magnetic sferics detectors, as well as optical systems and the above-mentioned near-zone detectors modified to also detect sferics. The sferics detectors sense electromagnetic fields radiated by lightning and pre-lightning discharges, and may be classified according to their applications as single-station bearing detectors (crossed loops-wideband or narrowband, multiple loops, time-of-arrival and interferometer systems), and as single-station range detectors (crossed loops, 500 KHz pulse-height, spectral-amplitude-ratio/group-delay-difference, electric amplitude, e.g.,  $1/r$ -cubed, and ratio-of-magnetic-to-electric-amplitude systems). Many of the systems surveyed have virtues warranting their consideration, as individuals or in combinations, for airborne warning and avoidance application. However, they all have advantages and disadvantages that require further investigation, careful testing and evaluation. GRA

**N81-20046#** Lockheed-Georgia Co., Marietta. Engineering Systems Analysis Div.

**ISSUES OF COMMONALITY. VOLUME 2: ISSUE ANALYSIS Final Report**

W. T. Garrett, J. R. Atcheson, D. L. Bouguet, W. A. French, C. R. Needles, R. P. Tuttle, and S. M. Williams Dec. 1980 145 p refs

(Contract F33615-78-C-0115) (AD-A095418; LG80ER0013-VOL-2) Avail: NTIS HC A07/MF A01 CSCL 01/3

Since 1974, when the Military Airlift Command proposed the concept of commonality between civil and military transport airplanes, the Air Force has sponsored various studies on the technical feasibility, cost effectiveness, and design trade-offs for a large, advanced technology, transport aircraft. Originally designated C-XX, but now known as the ACMA (Advanced Civil/Military Aircraft), such aircraft would have the potential to meet not only the strategic military airlift needs of the United States at reduced investment, operating, and support costs; but would also provide the worldwide civilian cargo industry with more efficient airfreight capabilities. There are many important institutional issues related to the acceptance of a joint civil/military development concept due to the numerous and significant interactions between government (both military and domestic agencies), in industry (both manufacturers and air carriers), and international aviation interests. These interactions, and the

potential conflicts, are the central focus of the Issues of Commonality Study. This report summarizes the work performed to date. GRA

**N81-20047#** Lockheed-Georgia Co., Marietta. Engineering Systems Analysis Div.

**ISSUES OF COMMONALITY. VOLUME 1: EXECUTIVE SUMMARY Final Report**

W. T. Garrett, J. R. Atcheson, D. L. Bouguet, W. A. French, C. R. Needles, R. P. Tuttle, and S. M. Williams Dec. 1980 20 p (Contract F33615-78-C-0115)

(AD-A095417; LG80ER0013-VOL-1) Avail: NTIS HC A02/MF A01 CSCL 01/3

The Issues of Commonality Study examines the significant institutional issues related to the acceptance of a concept for the development of a new large cargo aircraft. The proposed aircraft, referred to as the ACMA (Advanced Civil/Military Aircraft), nee C-XX is conceived as an advanced technology transport with the potential for fulfilling both the U.S. need for military airlift and the worldwide need for commercial airfreight in the 1990s and beyond. There are many political and socio-economic considerations to be addressed when formulating a program involving government and industry participants with their particular and diverse interests. This study focuses on these interfaces and potential problem areas and examines four issues thought to be of more immediate concern to the successful initiation of a joint civilian/military venture. These issues are: establishing the commercial need, U.S. and international; development of a financial planning concept; energy considerations that may impact the program; and impact of engine development/acquisition. GRA

**N81-20050\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**OPERATIONAL CONSIDERATIONS IN UTILIZATION OF MICROWAVE LANDING SYSTEM APPROACH AND LANDING GUIDANCE**

William F. White and Leonard V. Clark Mar. 1981 33 p refs Presented at the 1980 Aircraft Safety and Operating Probl. Conf., Hampton, Va., 5-7 Nov. 1980 Submitted for publication (NASA-TM-81945; L-14330) Avail: NTIS HC A03/MF A01 CSCL 17G

The characteristics of microwave landing system (MLS) equipment are reviewed and the flight performance of the terminal configured vehicle B-737 airplane during nearly five years of flight experience with MLS is summarized. Most of these flights involved curved, descending flight paths with automatic landings and final approaches as short as 0.44 n. mi. Possible uses to solve noise abatement problems with MLS equipment of varying degrees of complexity are discussed. It is concluded that altitude derived from MLS is superior to other sources near the airport traffic pattern. E.A.K.

**N81-20051\*#** Analytical Mechanics Associates, Inc., Mountain View, Calif.

**GENERATION OF OPTIMUM VERTICAL PROFILES FOR AN ADVANCED FLIGHT MANAGEMENT SYSTEM Final Report**

John A. Sorensen and Mark H. Waters Mar. 1981 153 p refs

(Contract NAS1-15497) (NASA-CR-165674) Avail: NTIS HC A08/MF A01 CSCL 17G

Algorithms for generating minimum fuel or minimum cost vertical profiles are derived and examined. The option for fixing the time of flight is included in the concepts developed. These algorithms form the basis for the design of an advanced on-board flight management system. The variations in the optimum vertical profiles (resulting from these concepts) due to variations in wind, takeoff mass, and range-to-destination are presented. Fuel savings due to optimum climb, free cruise altitude, and absorbing delays enroute are examined. E.D.K.

**N81-20055#** Massachusetts Inst. of Tech., Cambridge.

**INITIAL DESIGN AND EXPERIMENTAL IMPLEMENTATION OF THE TRAFFIC ADVISORY SERVICE OF ATARS**

Jeffrey L. Gertz 3 Nov. 1980 148 p refs  
(Contracts F19628-80-C-0002; DOT-FA72-WAI-261)  
(AD-A095462; ATC-101; FAA-RD-80-117) Avail: NTIS  
HC A07/MF A01 CSCL 17/7

The FAA Automatic Traffic Advisory and Resolution Service (ATARS) is a ground-based collision avoidance system which utilizes surveillance data from the Discrete Address Beacon System (DABS). It computes traffic advisories and collision warnings using a ground computer independent of the ATC computer system, and delivers these messages to aircraft via the DABS data link. ATARS provides both a traffic advisory and a resolution (collision avoidance) service to aircraft equipped with a DABS transponder, an altitude encoder (mode C), and an ATARS display. The objective of the ATARS effort reported was the design of a traffic advisory service that complements the ground based resolution service while being compatible with the other applications being developed for the DABS data link. The main technical issue was the construction of a set of message formats that provides the pilot with all information he requires while minimizing data link loading. Furthermore, this message set had to support a wide spectrum of onboard equipment, from a simple ring of lights to a sophisticated graphics system. GRA

**N81-20056#** Federal Aviation Administration, Atlantic City, N.J.  
**FLIGHT TESTS OF THE MICROWAVE LANDING SYSTEM**  
**MULTIMODE DIGITAL PROCESSOR** Final Report, Aug. -  
Nov. 1980

John Warren Jan. 1981 75 p refs  
(AD-A095449; FAA-CT-80-19) Avail: NTIS  
HC A04/MF A01 CSCL 17/7

Flight tests were performed in order to evaluate four digital airborne processing techniques. Four techniques used for processing Microwave Landing System (MLS) time reference scanning beam (TRSB) signals are: (1) dwell-gate processing (DGP), (2) single-edge processing (SEP), (3) dual-edge processing (DEP), and (4) splitgate processing (SPGT). These techniques were flight tested under standard partial orbits, glide slopes, and aircraft shadowing. Overall, the SPGT and DGP techniques resulted in about the same errors. The SEP data were noisier than the DGP but usually had about the same bias. The DEP technique was always inferior to the DGP. Aircraft shadowing errors were excessive for all techniques and should be avoided by operating procedures when an aircraft nears the touchdown region. It is recommended that the DEP algorithm be changed for improved noise performance and flight tests be performed using all four processing techniques in a specular multipath environment and under conditions using two azimuth antennas having different beam widths (these tests were not performed because of equipment nonavailability during flight testing). GRA

**N81-20058#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugmechanik.

**EVALUATION OF THE VISUAL ACQUISITION RANGE OF EN-ROUTE AIR TRAFFIC FROM COCKPIT OBSERVATIONS**

Otto Weber Sep. 1980 54 p refs In GERMAN; ENGLISH summary Original report in GERMAN will also be announced as translation (ESA-TT-691)

(DFVLR-Mitt-80-14) Avail: NTIS HC A04/MF A01

On-board observations and approach head time measurements are employed. The results of 29 measurement campaigns conducted by airline pilots are analyzed. Evaluation method are described and problems due to converging courses and large cross track distances in the head-on case are treated in detail. The results for the acquisition range and the apparent size of the intruder derived from this range are discussed. The advantages of anticollision and position lights, vapor trails and air traffic control signals for the acquisition process are demonstrated. Proposals for improving data acquisition in the future are included. Author (ESA)

**N81-20059#** National Aerospace Lab., Amsterdam (Netherlands). Flight Div.

**THE SEMI-OPERATIONAL EVALUATION OF THE TRAJECTORY PREDICTION METHOD FOR SIGNAL AUTOMATIC RADAR PROCESSING (SARP) 2**

J. M. tenHave Sep. 1979 16 p refs Presented at 6th SPACDAR Meeting, Brussels, 7-9 Nov. 1979 Sponsored by Netherlands Civil Aviation Dept. (RLD)

(NLR-MP-79038-U) Avail: NTIS HC A02/MF A01

Results of the evaluation under semi-operational conditions of the SARP 2 trajectory prediction method are presented. Flight data of some 1000 inbound, outbound and transit flights in the Netherlands FIR were analyzed. In the SARP 2 software, the elapsed time computations for the successive reporting points are based on the ground speed of the aircraft and the lengths of the straight segments connecting these reporting points. Ground speed is computed using true airspeed obtained from the filed flight plan or stored aircraft performance data and the wind component. The design objective of 120 sec was achieved in most cases. Trajectory prediction is acceptable in the present SARP environment. For inbound, outbound, and transit flights, 60 to 70% of the aircraft show a trajectory computation error less than 45 seconds. The mean value of the time errors is rather small, while the standard deviation is comparatively large. Possible improvements are proposed, based on more extensive use of radar and flight plan data. Author (ESA)

**N81-20060** Michigan Univ., Ann Arbor.  
**OPTIMUM MANEUVERS OF SUPERSONIC AIRCRAFT,**  
**VOLUMES 1 AND 2** Ph.D. Thesis  
Ching-Fang Lin 1980 560 p

Avail: Univ. Microfilms Order No. 8106178

Several optimum maneuvers of supersonic aircraft are investigated. Topics include optimum supersonic cruise; minimum time, minimum radius, and minimum fuel turns on a horizontal plane; and optimum maneuvers on a vertical plane which consist of maximum range glide, minimum time zoom climb, minimum time loop, Immelman, and Split-S maneuvers. The discussion emphasizes the analytic aspect of the theory. This has the advantage of a general discussion of any particular problem since the behavior of the optimal control does not depend on any particular measuring system, but rather on a certain number of important dimensionless performance parameters which need to be displayed explicitly. When necessary, numerical solutions are presented to show the quantity, and furthermore, the quality behavior of the optimal trajectory and the optimal control to guide the aircraft along a particular trajectory. In order to facilitate smooth application of the optimal control theory to analyze a wide range of flight programs of practical interest, two mathematical modelings of the aerodynamic and engine characteristics are designed in the form of a lightweight fighter called the supercruiser and a rocket powered aircraft by which dimensionless equations of motion for three dimensional flight over a flat earth are derived. Dissert. Abstr.

**N81-20061** Oregon State Univ., Corvallis.  
**APPLICATION OF LINEAR QUADRATIC CONTROL IN REDUCTION OF AERODYNAMIC FORCES ON AIRCRAFT**  
Ph.D. Thesis

Shou Yuan Wei 1981 277 p

Avail: Univ. Microfilms Order No. 8105191

A problem found in high speed transport aircraft is excessive tail loading when flying at cruise speeds through turbulence. Attempts to reduce these aerodynamic forces on the tail may result in unstable aircraft motions. Using a linear quadratic regulator in conjunction with a Kalman filter, the feasibility of designing an autopilot utilizing the ailerons and rudder is studied in terms of minimal combined lateral ride motion and aerodynamic tail force. A numerical algorithm for solving general quadratic regulator and state estimation problems is developed, and is presented with a computer program to solve the complicated matrix equations involved. A systematic procedure is developed for choosing a reduced combination of sensors which gives near optimal performance. With this approach, aerodynamic tail forces can be theoretically reduced by 20 to 50 percent. Dissert. Abstr.

**N81-20062#** Boeing Commercial Airplane Co., Seattle, Wash. Preliminary Design Dept.

**INTEGRATED APPLICATION OF ACTIVE CONTROLS (IAAC) TECHNOLOGY TO AN ADVANCED SUBSONIC TRANSPORT: PROJECT PLAN** Final Report

Washington NASA Feb. 1981 43 p  
(Contracts NAS1-14742; NAS1-15325)  
(NASA-CR-3305; D6-46691) Avail: NTIS HC A03/MF A01  
CSCL 01C

The state of the art of active controls technology (ACT) and a recommended ACT development program plan are reviewed. The performance benefits and cost of ownership of an integrated application of ACT to civil transport aircraft is to be assessed along with the risk and laboratory and/or flight experiments designed to reduce the technical risks to a commercially acceptable level.  
E.A.K.

**N81-20063\*** # ECON, Inc., San Jose, Calif.  
**STUDY OF MATERIALS PERFORMANCE MODEL FOR AIRCRAFT INTERIORS Final Report**  
K. Leary and J. Skratz 31 Aug. 1980 86 p  
(Contract NAS2-10515)  
(NASA-CR-152378) Avail: NTIS HC A05/MF A01 CSCL 01C

A demonstration version of an aircraft interior materials computer data library was developed and contains information on selected materials applicable to aircraft seats and wall panels, including materials for the following: panel face sheets, bond plies, honeycomb, foam, decorative film systems, seat cushions, adhesives, cushion reinforcements, fire blocking layers, slipcovers, decorative fabrics and thermoplastic parts. The information obtained for each material pertains to the material's performance in a fire scenario, selected material properties and several measures of processability.  
T.M.

**N81-20064** # Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).  
**APPLICATION OF A STRUCTURAL OPTIMIZATION PROCEDURE FOR ADVANCED WINGS**  
H. Godel (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) and G. Schneider (Messerschmitt-Boelkow Blohm GmbH, Munich, West Germany) Jan. 1981 20 p refs Presented at the 51st Meeting of the AGARD Struct. and Mater. Panel, Aix-en-Provence, France, 14-19 Sep. 1980  
(AGARD-R-691; ISBN-92-835-1379-7) Avail: NTIS HC A02/MF A01

A computer software called ASAT exists which allows an automatic design of minimum weight structures. The application of the system to several structures is described. It is shown that a structural optimization system can be very useful in the preliminary design of an airplane, especially when it consists of several modules such as static load calculation, deformations and stress calculation by finite elements, static aeroelastics, weight calculation, unsteady aerodynamic forces, vibration calculation, flutter calculation, flutter, and strength optimization which all can be used separately and independently.  
E.D.K.

**N81-20065\*** # Mississippi State Univ., Mississippi State.  
**INVESTIGATION OF FLIGHT TEST METHODS FOR MEASURING THE PERFORMANCE OF GENERAL AVIATION AIRCRAFT Semiannual Status Report, 1 Jul. 1980 - Feb. 1981**  
Gifford Bull and Philip D. Bridges 1981 17 p  
(Grant NAG1-3)  
(NASA-CR-164057) Avail: NTIS HC A02/MF A01 CSCL 01C

A theoretical and experimental investigation of methods for measuring the performance of general aviation airplanes was conducted using relatively simple instrumentation currently available and data extraction techniques established from efforts in other disciplines. The possibilities of improving flight test data by use of improved modern instrumentation and digital data recording and data analysis were considered.  
E.D.K.

**N81-20066\*** # National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif.  
**RECENT PROGRESS IN V/STOL AIRCRAFT TECHNOLOGY Final Report**  
L. Roberts, W. Deckert, and D. Hickey Mar. 1981 13 p refs  
(NASA-TM-81281; A-8512) Avail: NTIS HC A02/MF A01 CSCL 01C

Results from wind tunnel and flight tests investigations for V/STOL aircraft are reviewed. Primary emphasis is given to technical results relating to three types of subsonic aircraft: a quiet STOL aircraft; a tilt rotor aircraft; and a turboprop V/STOL aircraft. Comparison and correlation between theoretical and experimental results and between wind tunnel and flight test results, is made. The quiet STOL aircraft technology results are primarily those derived from the NASA/Boeing Quiet Short Haul Technology (QSRA) program. The QSRA aircraft uses an upper surface blown flap and develops a usable engine-out landing approach lift coefficient of 5.5 and landing distances less than 1,000 ft. The tilt rotor aircraft technology results are those obtained from the NASA/Army/Navy/Bell (XV-15-TRRA) aircraft flight investigations. The TRRA is a twin rotor research aircraft capable of vertical takeoff and landing and cruise speeds of 300 knots. The turboprop V/STOL aircraft technology results are from static ground facility and wind tunnel investigations of a NASA/NAVY/Grumman full scale lift/cruise fan aircraft model, which features two tilting nacelles with TF-34 engines.  
Author

**N81-20067\*** # Kentron International, Inc., Hampton, Va.  
**A STUDY OF HIGH-ALTITUDE MANNED RESEARCH AIRCRAFT EMPLOYING STRUT-BRACED WINGS OF HIGH-ASPECT-RATIO**  
Paul M. Smith, John DeYoung, William A. Lovell, Jack E. Price, and G. Fred Washburn Feb. 1981 93 p refs  
(Contract NAS1-16000)  
(NASA-CR-159262) Avail: NTIS HC A05/MF A01 CSCL 01C

The effect of increased wing aspect ratio of subsonic aircraft on configurations with and without strut bracing. Results indicate that an optimum cantilever configuration, with a wing aspect ratio of approximately 26, has a 19% improvement in cruise range when compared to a baseline concept with a wing aspect ratio of approximately 10. An optimum strut braced configuration, with a wing aspect ratio of approximately 28, has a 31% improvement in cruise range when compared to the same baseline concept. This improvement is mainly due to the estimated reduction in wing weight resulting from use of lifting struts. All configurations assume the same mission payload and fuel. The drag characteristics of the wings are enhanced with the use of laminar flow airfoils. A method for determining the extent of attainable natural laminar flow, and methods for preliminary structural design and for aerodynamic analysis of wings lifting struts are presented.  
E.A.K.

**N81-20068\*** # Pennsylvania State Univ., University Park. Dept. of Aerospace Engineering.  
**THE PREDICTION OF NORMAL FORCE AND ROLLING MOMENT COEFFICIENTS FOR A SPINNING WING**  
Barnes W. McCormick Feb. 1981 22 p refs  
(NASA Order L-13435B)  
(NASA-CR-165680) Avail: NTIS HC A02/MF A01 CSCL 01C

Nonlinear airfoil section data for angles of attack from 0 to 180 deg were used in a small computer code to numerically integrate the section normal force coefficients along the span as a function of the local velocity and angle of attack resulting from the combined spinning and descending motion. A correction was developed to account for the radial pressure gradient in the separated, rotating flow region above the wing. This correction was found to be necessary in order to obtain agreement, both in form and magnitude, with rotary balance test data.  
T.M.

**N81-20069** # General Accounting Office, Washington, D. C.  
**THE F/A-18 NAVAL STRIKE FIGHTER: PROGRESS HAS BEEN MADE BUT PROBLEMS AND CONCERNS CONTINUE**  
18 Feb. 1981 41 p  
(AD-A095287; GAO/MASAD-81-3) Avail: NTIS HC A03/MF A01 CSCL 01/3

Contents: Technical problems still exist but progress has been made; F/A-18 reliability and maintainability continue to improve despite problem areas, and F/A-18 program costs are steadily increasing.  
GRA



**N81-20070#** Naval Air Development Center, Warminster, Pa. Aircraft and Crew Systems Technology Directorate.

**STATISTICAL REVIEW OF COUNTING ACCELEROMETER DATA FOR NAVY AND MARINE FLEET AIRCRAFT**  
**Semiannual Summary Report, 1 Jan. 1982 - 30 Jun. 1980**  
 Warren J. Williams 1 Nov. 1980 144 p

(AD-A095617; NADC-13920-2) Avail: NTIS HC A07/MF A01 CSCL 01/1

This report is a specialized summary of normal acceleration data recorded by counting accelerometers. Data are separated by calendar time and mission category. Only data reported in the counting accelerometer program are included. GRA

**N81-20071#** Rockwell International Corp., Cedar Rapids, Iowa. Collins Radio Group.

**DELTA ELECTRICAL LOAD ANALYSIS C-141B JACC/CP AIRCRAFT**

G. R. Taylor 1980 8 p  
 (Contract F09603-80-C-0602)

(AD-A095659) Avail: NTIS HC A02/MF A01 CSCL 01/3

The installation of the provisions to accept the JACC/CP Capsule in the C-141B Aircraft causes a change to the electrical loads within the present aircraft power distribution system. The purpose of this report is to furnish a tabulation of the changes to the aircraft power system caused by this installation. The electrical load changes to the C-141B aircraft power system caused by this installation are insignificant and causes minimum change to the available growth capacity. GRA

**N81-20072#** Rockwell International Corp., Dallas, Tex. Collins Radio Group.

**STRESS ANALYSIS OF AIRCRAFT MODIFICATIONS (C-141B AIRCRAFT). JOINT AIRBORNE COMMUNICATIONS CENTER/COMMAND POST (JACC/CP) PROVISIONS**

D. B. Ragan 27 Oct. 1980 158 p refs  
 (Contract F08603-80-C-0602)

(AD-A095634) Avail: NTIS HC A08/MF A01 CSCL 01/3

Stress analyses were performed on the following aircraft modifications: AT1108 Antenna Installation, HF Longwire Installation, UPS-192 Antenna Installation, 437S-1C Antenna Installation, and SATCOM Antenna Installation. The detailed conclusions of each of the topics above are contained after each sub-analysis. However, the general conclusion is that each of the subject modifications in no way impare the airworthiness of the aircraft in that the aircraft strength is equal to or greater than the original unmodified strength. GRA

**N81-20073#** Air Force Packaging Evaluation Agency, Wright-Patterson AFB, Ohio.

**TEST AND EVALUATION OF FOAM-IN-PLACE FUEL TANK CONTAINER Progress Report, Nov. - Dec. 1980**

Shui-Nan Chuang Dec. 1980 24 p  
 (AD-A095747; PTPD-80-22) Avail: NTIS HC A02/MF A01 CSCL 13/4

One single pack, F-100 aircraft, 200 gallon fuel tank foam-in-place (FIP), reusable container fabricated by Instapak, Sealed Air Corporation, Danbury CN 06810 was tested by the Air Force Packaging Evaluation Agency (AFPEA), Wright-Patterson AFB OH 45433. The container was tested IAW Federal Test Method Standard (FTMS) 101B, MIL-STD-810C and MIL-P-116G. Although a crack, with a maximum 1/2 in. gap, across the bottom section of the container resulted from the temperature shock test, the container passed all of the requirements as specified for this project except the cyclic exposure test. Improvements resulting from this evaluation will be incorporated into the fabrication of two additional prototype containers for the F-4 aircraft, 370 and 600 gallon fuel tanks. GRA

**N81-20074\*#** National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, Calif.

**DIVERSITY TECHNIQUES FOR OMNIDIRECTIONAL TELEMETRY COVERAGE OF THE HIMAT RESEARCH VEHICLE**

Paul F. Harney Mar. 1981 18 p refs  
 (NASA-TP-1830; H-1133) Avail: NTIS HC A02/MF A01 CSCL 09F

The highly maneuverable aircraft technology (HiMAT) remotely piloted research vehicle (RPRV) was flight tested and a number of technological advances applicable to future fighter aircraft were demonstrated. The aircraft control system uses airborne and ground-based computers which communicate via uplink and downlink telemetry. Antenna radiation patterns are normally much less than ideal for continuous reception or transmission for all aircraft attitudes. After flight qualification and testing on other aircraft, a frequency diversity concept and an antenna diversity concept were implemented on the HiMAT vehicle to obtain omnidirectional telemetry coverage. E.A.K.

**N81-20075#** Army Test and Evaluation Command, Aberdeen Proving Ground, Md.

**TESTING AIRCRAFT INSTRUMENTS Final Report**

11 Feb. 1981 26 p refs

(AD-A095680; TOP-6-3-013) Avail: NTIS HC A03/MF A01 CSCL 01/4

This TOP establishes procedures and provides guidance for the functional testing of aircraft instruments and for the testing of the logistics support system required to return aircraft instruments to proper functioning condition after failure. Aircraft instruments include basic flight and aircraft systems performance/health indicators. Functional testing implies the test item is properly installed in the appropriate aircraft and evaluated throughout the operational range of the aircraft mission scenario. The primary objectives of this TOP are: (a) To determine if the designated aircraft instrument performs its intended function in accordance with the requirements presented in the applicable approved documents; Letter Requirement (LR), Letter of Agreement (LOA), Required Operational Characteristics (ROC), Material Needs (MN), etc., as reflected through the TECOM Test Directive; (b) To evaluate the human factors engineering (HFE) functional characteristics; and (c) To evaluate the installation and operational compatibility of the designated aircraft instrument with the aircraft interface, other instruments, and aircraft systems. GRA

**N81-20076\*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**REASONS FOR LOW AERODYNAMIC PERFORMANCE OF 13.5-CENTIMETER-TIP-DIAMETER AIRCRAFT ENGINE STARTER TURBINE**

Jeffrey E. Haas, Richard J. Roelke, and Paul Hermann (Sundstrand Corp., Rockford, Ill.) Mar. 1981 18 p Presented at the SAE Aerospace Meeting, Los Angeles, 13-16 Oct. 1980

(NASA-TP-1810; E-540; AVRADCOM-TR-80-C-17) Avail: NTIS HC A02/MF A01 CSCL 21E

The reasons for the low aerodynamic performance of a 13.5 cm tip diameter aircraft engine starter turbine were investigated. Both the stator and the stage were evaluated. Approximately 10 percent improvement in turbine efficiency was obtained when the honeycomb shroud over the rotor blade tips was filled to obtain a solid shroud surface. Efficiency improvements were obtained for three rotor configurations when the shroud was filled. It is suggested that the large loss associated with the open honeycomb shroud is due primarily to energy loss associated with gas transportation as a result of the blade to blade pressure differential at the tip section. E.A.K.

**N81-20077** General Accounting Office, Washington, D. C.  
**A LOOK AT NASA'S AIRCRAFT ENERGY EFFICIENCY PROGRAM**

General Accounting Office 28 Jul. 1980 4 p  
 (PSAD-80-50) Avail: NTIS HC A02/MF A01

The status of the Aircraft Energy Efficiency (ACEE) program the coordination effectiveness between NASA and the Department of Defense (DOD), the need for periodic reporting to the Congress on efforts as ACEE, and NASA's role in aeronautical R&D are examined. The ACEE program accounted for over one third of NASA's aeronautical budget for fiscal year 1980 and will decrease to 29 percent in fiscal year 1981. Details on ACEE costs and funding for NASA's aeronautical research and technology program are appended. E.A.K.

**N81-20078\*** Pratt and Whitney Aircraft, West Palm Beach, Fla. Government Products Div.

**EXTENDED FREQUENCY TURBOFAN MODEL Final Report**

J. R. Mason, J. W. Park, and R. F. Jaekel 15 Dec. 1980 104 p refs

(Contract NAS3-21807)

(NASA-CR-185281; FR-13983)

Avail: NTIS

HC A06/MF A01 CSCL 21E

The fan model was developed using two dimensional modeling techniques to add dynamic radial coupling between the core stream and the bypass stream of the fan. When incorporated into a complete TF-30 engine simulation, the fan model greatly improved compression system frequency response to planar inlet pressure disturbances up to 100 Hz. The improved simulation also matched engine stability limits at 15 Hz, whereas the one dimensional fan model required twice the inlet pressure amplitude to stall the simulation. With verification of the two dimensional fan model, this program formulated a high frequency F-100(3) engine simulation using row by row compression system characteristics. In addition to the F-100(3) remote splitter fan, the program modified the model fan characteristics to simulate a proximate splitter version of the F-100(3) engine. T.M.

**N81-20079\*** Iowa State Univ. of Science and Technology, Ames. Engineering Research Staff.

**AERODYNAMICS OF ADVANCED AXIAL-FLOW TURBO-MACHINERY Final Report, 1 Oct. 1978 - 30 Sep. 1980**

George K. Serovy, Patrick Kavanagh, and Theodore H. Kiishi 30 Nov. 1980 93 p refs Sponsored in part by NASA

(Contract F49620-79-C-0002; AF Proj. 2307)

(NASA-CR-163995; AD-A095705; ISU-ERI-AMES-81104;

TCRL-17; AFOSR-81-0109TR) Avail: NTIS HC A05/MF A01 CSCL 20/4

A multi-task research program on aerodynamic problems in advanced axial-flow turbomachine configurations was carried out at Iowa State University. The elements of this program were intended to contribute directly to the improvement of compressor, fan, and turbine design methods. Experimental efforts in intra-passage flow pattern measurements, unsteady blade row interaction, and control of secondary flow are included, along with computational work on inviscid-viscous interaction blade passage flow techniques. This final report summarizes the results of this program and indicates directions which might be taken in following up these results in future work. In a separate task a study was made of existing turbomachinery research programs and facilities in universities located in the United States. Some potentially significant research topics are discussed which might be successfully attacked in the university atmosphere. GRA

**N81-20080\*** Pratt and Whitney Aircraft Group, West Palm Beach, Fla. Government Products Div.

**CONCEPT DEFINITION: RETIREMENT FOR CAUSE OF F-100 ROTOR COMPONENTS Final Report, Jun. 1977 - Mar. 1980**

J. A. Harris, Jr., D. L. Sims, and C. G. Annis, Jr. Sep. 1980 46 p refs

(Contract F33615-76-C-5172; AF Proj. 7351)

(AD-A095584; PWA-FR-13144; AFWAL-TR-80-4118) Avail: NTIS HC A03/MF A01 CSCL 21/5

Historically, gas turbine engine disks are retired when they accrue an analytically determined lifetime where the first fatigue crack per 1000 disks could be expected. By definition then, 99.9% of these components are being retired prematurely. Retirement-for-cause (RFC) is a procedure, based on fracture mechanics, which would allow safe utilization of the full life capacities of each individual disk. Since gas turbine disks are among the most costly of engine components, adopting a RFC philosophy could result in substantial systems life cycle cost savings. These would accrue from reduced replacement costs, conservation of strategic materials such as cobalt, and energy savings. This study addresses the application of this concept to the USAF F100 engine. GRA

**N81-20081\*** Rolls-Royce Ltd., Derby (England).

**THE OPTIMUM DESIGN OF BY-PASS ENGINES WITH JET MIXING**

Albrecht Hartmann (Technische Hochschule, Aachen) 1980 18 p refs

(PNR-90017; Trans-15028) Avail: NTIS HC A02/MF A01

The advantages of mixing exhaust and by-pass flow in a by-pass engine are studied. Computer calculations are presented showing the influences of primary flow pressure ratio, gas temperature in front of the turbine, by-pass ratio, and of nacelle drag on engine performance. Thrust and efficiency of the various configurations are discussed. The influence of a limited mixing chamber cross-section and of partial mixing is also analyzed.

Author (ESA)

**N81-20082\*** National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

**AN ANALYTICAL STUDY OF THE LONGITUDINAL RESPONSE OF AIRPLANES TO POSITIVE WIND SHEAR**

Windsor L. Sherman Mar. 1981 51 p refs

(NASA-TP-1765; L-13623) Avail: NTIS HC A04/MF A01 CSCL 01C

The longitudinal response of jet transport aircraft to vertical variation of the horizontal winds is analyzed. Specific reference is given to the role of the speed (u) stability derivatives in the interaction of the airplane and its environment. The relative importance of the u stability derivatives is determined. The wind shear tolerance factor is found which can be used to determine, in a qualitative manner, the stability (tolerance) of an airplane to wind shear. A further study of the control problem shows that the criteria for good control could be reduced from two to one automatic control systems. Only a speed control system is necessary for good control in wind shear. M.G.

**N81-20083\*** National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

**OPERATING CHARACTERISTICS OF THE LANGLEY MACH 7 SCRAMJET TEST FACILITY**

Robert W. Guy, Marvin G. Torrence, Alexander P. Sabol, and James N. Mueller Mar. 1981 56 p refs

(NASA-TM-81929; L-14174) Avail: NTIS HC A04/MF A01 CSCL 14B

Operating characteristics of the Langley Mach 7 Scramjet Test Facility are described. The facility is designed for testing airframe integrated scramjet (supersonic combustion ramjet) engine models. Features include duplication of the flight Mach number total enthalpy, flight altitude simulation, and simulation of engine airframe integration effects such as a bow shock wave precompression and boundary layer ingestion by the engine. Data obtained from facility calibration and from tests of a hydrogen burning, airframe integrated scramjet are discussed. An adverse interaction between the facility flow and the scramjet engine flow during combustion of the fuel is described. E.A.K.

**N81-20084\*** National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

**SUPPORT INTERFERENCE OF WIND TUNNEL MODELS: A SELECTIVE ANNOTATED BIBLIOGRAPHY**

Marie H. Tuttle and Blair B. Gloss Mar. 1981 36 p

(NASA-TM-81909; L-14198) Avail: NTIS HC A03/MF A01 CSCL 14B

This bibliography, with abstracts, consists of 143 citations arranged in chronological order by dates of publication. Selection of the citations was made for their relevance to the problems involved in understanding or avoiding support interference in wind tunnel testing throughout the Mach number range. An author index is included. Author

**N81-20085\*** National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

**COMMENTS ON SETTLING CHAMBER DESIGN FOR QUIET, BLOWDOWN WIND TUNNELS**

I. E. Beckwith Mar. 1981 41 p refs

(NASA-TM-81948) Avail: NTIS HC A03/MF A01 CSCL 14B

Transfer of an existing continuous circuit supersonic wind tunnel to Langley and its operation there as a blowdown tunnel is planned. Flow disturbance requirements in the supply section and methods for reducing the high level broad band acoustic disturbances present in typical blowdown tunnels are reviewed.

Based on recent data and the analysis of two blowdown facilities at Langley, methods for reducing the total turbulence levels in the settling chamber, including both acoustic and vorticity modes, to less than one percent are recommended. The pertinent design details of the damping screens and honeycomb and the recommended minimum pressure drop across the porous components providing the required two orders of magnitude attenuation of acoustic noise levels are given. A suggestion for the support structure of these high pressure drop porous components is offered. J.D.H.

**N81-20086\*** Massachusetts Inst. of Tech., Cambridge. Aerophysics Lab.

**APPLICATION OF SUPERCONDUCTING COILS TO THE NASA PROTOTYPE MAGNETIC BALANCE Final Report, 1 Jan. 1977 - 31 Aug. 1980**

C. W. Haldeman, R. A. Kraemer, S. W. Phey, M. M. Alishahi, and E. E. Covert Jan. 1981 144 p refs

(Grant NsG-1356)

(NASA-CR-165660; MIT-TR-207) Avail: NTIS HC A07/MF A01 CSCL 14B

Application of superconducting coils to a general purpose magnetic balance was studied. The most suitable currently available superconducting cable for coils appears to be a bundle of many fine wires which are transposed and are mechanically confined. Sample coils were tested at central fields up to .5 Tesla, slewing rates up to 53 Tesla/sec and frequencies up to 30 Hz. The ac losses were measured from helium boil-off and were approximately 20% higher than those calculated. Losses were dominated by hysteresis and a model for loss calculation which appears suitable for design purposes is presented along with computer listings. Combinations of two coils were also tested and interaction losses are reported. Two feasible geometries are also presented for prototype magnetic balance using superconductors. E.A.K.

**N81-20099#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

**VISUAL SYSTEM TECHNOLOGY: STATUS AND PROBLEMS**

In its Fidelity of Simulation for Pilot Training Dec. 1980 p 54-60

Avail: NTIS HC A04/MF A01

A list is presented of visual factors relevant to aircraft operation. Some target values for these factors are presented which, while a degradation from the absolute characteristics of the real world and of human perception, if achieved would provide visual information indistinguishable in practice from reality. Four basic systems are discussed: computer-generated imagery; camera/modelboards; film (photographic); and shadowgraph. T.M.

**N81-20193#** Bristol Univ. (England). Dept. of Aeronautical Engineering.

**SCARF JOINTS IN UNIDIRECTIONAL CARBON FIBER REINFORCED PLASTICS B.S. Thesis**

N. A. D. Murphy and M. G. Thornton Jun. 1980 56 p refs Sponsored by British Gliding Assoc. (BU-258) Avail: NTIS HC A04/MF A01

A method for repairing unidirectional carbon fiber reinforced plastic (CFRP) spar booms was investigated. An application of CFRP tests was carried out on the basic material to determine its mechanical properties and on tensile specimens repaired using the proposed scarf joint method. Theoretical models were developed to support these tests. The scarf tip is found to be the critical area, with the highest stresses and greatest sensitivity to material quality and finish. Some form of additional binding of the tip fibers appears to be necessary. Results suggest that repaired strengths of up to 60% of the original strength can be obtained, with a wet-dry repair, subject to quality of material and repair, using slopes in excess of 1 in 50. Author (ESA)

**N81-20245\*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**EFFECTS OF GEOMETRIC VARIABLES ON RUB CHARACTERISTICS OF Ti-6Al-4V**

Robert C. Bill, Jan Wolak (Washington Univ., Seattle), and Donald W. Wisander Apr. 1981 21 p refs Prepared in cooperation

with Army Aviation Research and Development Command, Cleveland, Ohio

(NASA-TP-1835; AVRADCOM-TR-80-C-19; E-449) Avail: NTIS HC A02/MF A01 CSCL 11F

Experiments simulating rub interactions between Ti-6Al-4V blade tips and various seal materials were conducted. The number of blade tips and the blade tip geometry were varied to determine their effects on rub forces and on wear phenomena. Contact was found to be quite unsteady for all blade tip geometries except for those incorporating deliberately rounded blade tips. The unsteady contact was characterized by long periods of rubbing contact and increasing blade tip that terminated in sudden rapid metal removal, sometimes accompanied by tearing and disruption of porous seal material under the rub surface. A model describing the blade tip loading is proposed and is based on the propagation of an elastic stress wave through the seal material as the seal material is dynamically compressed by the blade tip leading edge. E.D.K.

**N81-20322#** Radio Technical Commission for Aeronautics, Washington, D. C.

**MINIMUM OPERATIONAL PERFORMANCE STANDARDS FOR AIRBORNE RADAR APPROACH AND BEACON SYSTEMS FOR HELICOPTERS**

19 Nov. 1980 105 p

(RTCA/DO-172; LC-80-60000206) Avail: NTIS MF A01; HC \$16.00 from RTCA Secretariat Suite 655, 1717 H Street, N.W., Washington, D.C. 20006

Minimum operational performance standards are presented for airborne radar approach systems based on operational requirements of helicopters in the approach, missed approach, and departure modes, particularly during instrument flight rules, instrument meteorological conditions and at night. Included are those system characteristics pertinent to the airborne equipment and to the ground-based radar beacon for those operations requiring such equipment. Operational goals were established based on future requirements and technology, rather than merely repeating current state-of-the-art criteria. M.G.

**N81-20323#** Radio Technical Commission for Aeronautics, Washington, D. C.

**MINIMUM OPERATIONAL PERFORMANCE STANDARDS FOR AIRBORNE WEATHER AND GROUND MAPPING PULSED RADARS**

19 Nov. 1980 79 p Supersedes RTCA/DO-134

(RTCA/DO-173; RTCA/DO-134; LC-80-60000205) Avail: NTIS MF A01; HC \$16.00 from RTCA Secretariat, Suite 655, 1717 H Street, N.W., Washington, D.C. 20006

Minimum operational performance standards for airborne weather and ground mapping pulsed radars, including both air carrier and large aircraft-type radar systems, are described. Those requirements and technologies pertinent to general aviation, where limitations on space and/or weight may apply are taken into account. M.G.

**N81-20345#** Ohio State Univ., Columbus. ElectroScience Lab.

**ELECTROMAGNETIC SCATTERING BY OPEN CIRCULAR WAVEGUIDES Ph.D. Thesis**

T. W. Johnson and D. L. Moffatts Dec. 1980 133 p refs

(Contract N00014-78-C-0049)

(AD-A095554; ESL-710816-9)

Avail: NTIS

HC A07/MF A01 CSCL 20/14

Open circular waveguides are used to model jet engine inlets. The exact Wiener-Hopf solution for scattering by a semi-infinite cylinder is studied in the resonance region, where the cylinder diameter is of the order of a wavelength. In particular, the Wiener-Hopf factorization functions are calculated by numerical integration and compared to various approximations, to define regions of validity. Scattering from the rim is studied as a function of frequency, incidence angle, and time. A ray-optic model for rim backscatter is discussed. The relative power absorption of the five lowest order waveguide modes is evaluated. Coupling of incident plane waves to waveguide modes, and radiation by these modes are shown to be related by reciprocity. The waveguide termination model for a jet engine assumes an incident wave-

guide mode strikes an axially symmetric cone on a flat plate. The various techniques for evaluating scattering by this structure are discussed, and the problem is solved for a few cases. GRA

**N81-20424\*** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**SPUTTERING AND ION PLATING FOR AEROSPACE APPLICATIONS**

T. Spalvins 1981 14 p refs Proposed for presentation at Natl. Conf. of the Am. Electroplaters Soc., Boston, 28 Jun. - 2 Jul. 1981

(NASA-TM-81726; E-778) Avail: NTIS HC A02/MF A01 CSCL 13H

Sputtering and ion plating technologies are reviewed in terms of their potential and present uses in the aerospace industry. Sputtering offers great universality and flexibility in depositing any material or in the synthesis of new ones. The sputter deposition process has two areas of interest: thin film and fabrication technology. Thin film sputtering technology is primarily used for aerospace mechanical components to reduce friction, wear, erosion, corrosion, high temperature oxidation, diffusion and fatigue, and also to sputter-construct temperature and strain sensors for aircraft engines. Sputter fabrication is used in intricate aircraft component manufacturing. Ion plating applications are discussed in terms of the high energy evaporant flux and the high throwing power. Excellent adherence and 3 dimensional coverage are the primary attributes of this technology. Author

**N81-20447\*** Army Materials and Mechanics Research Center, Watertown, Mass. Materials Testing Technology Div.  
**COMPUTER TECHNIQUES FOR ULTRASONIC INSPECTION Final Report**

James M. Smith Dec. 1980 16 p refs  
(AD-A095285; AMMRC-TR-80-57) Avail: NTIS HC A02/MF A01 CSCL 14/2

This paper will describe two prototype ultrasonic inspection systems developed in-house at the Army Materials and Mechanics Research Center (AMMRC). Both systems incorporate computers for data acquisition and analysis purposes. The first inspection instrument uses a 64-element transducer array and is capable of inspecting artillery shell rotating bands for unbonds at high inspection rates (less than 10 seconds per shell). The second instrument is designed to measure the nonmetallic inclusion content in steel billets. Steel 'cleanliness' measurements are important when high quality steel is required for critical gears and bearings in aircraft engines. GRA

**N81-20868\*** National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.  
**THE PASSIVE OPTICAL SAMPLE ASSEMBLY (POSA) ON STS-1**

Roger C. Linton Mar. 1981 17 p  
(NASA-TM-82407) Avail: NTIS HC A02/MF A01 CSCL 20F

The passive optical sample assembly (POSA) hardware, scheduled for the flight on orbital flight test 1 is described. The function of the instrument is aid in the assessment contamination hazards to sensitive payloads in the shuttle cargo bay. It consists of an array of passively deployed samples mounted on the development flight instrumentation pallet in the shuttle cargo bay. The directory of samples together with their intended measurements are presented. The plan for POSA data analysis is also given. R.C.T.

**N81-21010\*** De Havilland Aircraft Co. of Canada Ltd., Downsview (Ontario).

**STATIC TESTS OF THE J97 POWERED, EXTERNAL AUGMENTER V/STOL WIND TUNNEL MODEL**

D. B. Garland Feb. 1978 44 p refs  
(Contract NASw-2797)  
(NASA-CR-152403; DHC-DND-77-4) Avail: NTIS HC A03/MF A01 CSCL 01A

Results of the static testing (zero forward speed) of the J97-powered, external augmentor, large scale, V/STOL model are discussed. With a ground clearance of 7.5 feet, believed to have put the model essentially out of ground effect, a gross

thrust augmentation ratio of 1.80 at nozzle pressure ratio (NPR) = 3.0 was measured for the fuselage augmentor. A similar figure was apparent for the wing augmentor. An overall ratio of model thrust to bare engine thrust of 1.62 was determined at NPR = 3.0. The structural integrity of the model was well demonstrated and duct pressure losses were small. M.G.

**N81-21012\*** National Aerospace Lab., Tokyo (Japan).  
**A DESIGN OF MULTI-ELEMENT AEROFOILS FOR HIGH LIFT**

Masashi Shigemi Oct. 1980 16 p refs In JAPANESE; ENGLISH summary  
(NAL-TR-631) Avail: NTIS HC A02/MF A01

A method developed for multielement airfoils for high lift in an incompressible flow is presented. Most airplanes acquire high lift through flaps or slats. High lift is obtained by combining the velocity distribution with multielement airfoils. Velocity distribution for the upper surface of airfoils consists of two parts: uniform velocity distribution, and Wortmann's velocity distribution. The velocity distribution around the flap and the slat is determined by the geometry of the main element designed to meet the given velocity conditions. The geometry of the main element is created using the panel method for a two dimensional potential flow. The formula of the panel method is linearized approximately in terms of the coordinates. Three examples of multielement airfoils are presented and it is shown that a modification of the shape of the airfoil does not cause disadvantages to the velocity distribution. E.A.K.

**N81-21016\*** National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

**CHARTS FOR DETERMINING POTENTIAL MINIMUM SONIC-BOOM OVERPRESSURES FOR SUPERSONIC CRUISE AIRCRAFT**

Christine M. Darden Mar. 1981 49 p refs  
(NASA-TP-1820; L-14190) Avail: NTIS HC A03/MF A01 CSCL 01A

Charts which give an estimation of minimum achievable sonic-boom levels for supersonic cruise aircraft are presented. A minimization method based on modified linear theory was analyzed. Results show several combinations of Mach number, altitude, and aircraft length and weight. Overpressure and impulse values are given for two types of sonic boom signatures for each of these conditions: (1) a flat top or minimum overpressure signature which has a pressure plateau behind the initial shock, and (2) a minimum shock signature which allows a pressure rise after the initial shock. Results are given for the effects of nose shape. E.A.K.

**N81-21017\*** Rockwell International Corp., Columbus, Ohio.  
**A STUDY OF A VTOL THRUSTING EJECTOR IN LOW SPEED FLIGHT, VOLUME 1**

V. R. Stewart Mar. 1981 158 p refs  
(Contract NAS2-10494)  
(NASA-CR-166137-Vol-1; NR80H-102-Vol-1) Avail: NTIS HC A08/MF A01 CSCL 01A

Low speed aerodynamic characteristics of a thrust augmentor wing suitable for vertical operation were investigated. Wind tunnel test results on the ejector and a similar configuration with a blown flap are analyzed. The configurations represented a VTOL concept at conditions of thrust deflections required for low forward speed flight. The model tested had an unswept untapered wing. Specific data included normal longitudinal forces and moments, surface pressures, ejector exit surveys, and flow field surveys behind the wing. E.A.K.

**N81-21018\*** Rockwell International Corp., Columbus, Ohio.  
**A STUDY OF A VTOL THRUSTING EJECTOR IN LOW SPEED FLIGHT, VOLUME 2**

V. R. Stewart Mar. 1981 546 p refs  
(Contract NAS2-10494)  
(NASA-CR-166137-Vol-2; NR80H-102-Vol-2) Avail: NTIS HC A23/MF A01 CSCL 01A

An experimental investigation of V/STOL thrust augmentor wings in flight at slow forward speeds is reported. Two rectangular planforms of differing relative chord lengths were tested. The

augmenters were positioned in the aft portion of the wing to produce increases in circulation lift. Two blown flap configurations were tested for comparison. Surface pressures as well as total forces and moments were obtained on the semispan models at two flap deflections and a range of momentum coefficients. Tabulations of surveys at the pressure augments exit, downwash surveys downstream of the wing, and force and moment data are included. E.A.K.

**N81-21024\*** National Aeronautics and Space Administration, Washington, D. C.

**EXPERIMENTAL INVESTIGATION OF THE FLOW ON THE SUCTION SIDE OF A THIN DELTA WING**

Dietrich Hummel Mar. 1981 15 p refs Transl. into ENGLISH from Z. Flugwiss. (West Germany), v. 13, Jul. 1965 p 247-252 (Contract NASw-3198) (NASA-TM-75897) Avail: NTIS HC A02/MF A01 CSCL 01A

Surface oil flow patterns were photographed and pressure distribution measurements were carried out on a sharp edged delta wing of aspect ratio  $\lambda = 1.0$  in order to determine the influence of Reynolds number and of vortex breakdown on the flow on the suction side of the wing. The formation of the secondary vortex occurs due to separation of a laminar boundary layer in the front part of the wing and due to separation of a turbulent boundary layer in the rear part of the wing. In the case of turbulent separation, the secondary separation line is closer to the wing leading edge than in the laminar case. The position of the transition depends on the Reynolds number and on the angle of incidence. The breakdown of a vortex above the wing leads to a kink in the secondary separation line. Author

**N81-21027\*** National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

**FLUID MECHANICS MECHANISMS IN THE STALL PROCESS OF HELICOPTERS**

Warren H. Young, Jr. Mar. 1981 12 p refs Presented at Symp. on Numerical and Phys. Aspects of Aerodyn. Flows, Long Beach, Calif., 19-21 Jan. 1981 Prepared in cooperation with Army Aviation Research and Development Command, Hampton, Va. (NASA-TM-81956; USAAVRADCOM-TR-81-B-1) Avail: NTIS HC A02/MF A01 CSCL 01A

Recent experimental results from airfoils in the Mach number, Reynolds number, or reduced frequency ranges typical of helicopter rotor blades have identified the most influential flow mechanisms in the dynamic stall process. The importance of secondary shed vortices, downstream wake action, and the flow in the separated region is generally acknowledged but poorly understood. By means of surface pressure cross-correlations and flow field measurements in static stall, several new hypotheses have been generated. It is proposed that vortex shedding may be caused by acoustic disturbances propagating forward in the lower (pressure) surface boundary layer, that wake closure is a misnomer, and that the shed vortex leaves a trail of vorticity that forms a turbulent free shear layer. The known dynamic stall flow mechanisms are reviewed and the potential importance of recently proposed and hypothetical flow phenomena with respect to helicopter blade aeroelastic response are assessed. J.D.H.

**N81-21028\*** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**LOW AND HIGH SPEED PROPELLERS FOR GENERAL AVIATION: PERFORMANCE POTENTIAL AND RECENT WIND TUNNEL TEST RESULTS**

Robert J. Jeracki and Glenn A. Mitchell 1981 29 p refs Presented at the Natl. Business Aircraft Meeting, Wichita, Kan., 7-10 Apr. 1981; sponsored by SAE (NASA-TM-81745; E-799) Avail: NTIS HC A03/MF A01 CSCL 01A

The performance of lower speed, 5 foot diameter model general aviation propellers, was tested in the Lewis wind tunnel. Performance was evaluated for various levels of airfoil technology and activity factor. The difference was associated with inadequate modeling of blade and spinner losses for propellers round shank blade designs. Suggested concepts for improvement are:

(1) advanced blade shapes (airfoils and sweep); (2) tip devices (proplets); (3) integrated propeller/nacelles; and (4) composites. Several advanced aerodynamic concepts were evaluated in the Lewis wind tunnel. Results show that high propeller performance can be obtained to at least Mach 0.8. E.A.K.

**N81-21037#** Rolls-Royce Ltd., Derby (England).

**THE RB211 ENGINE AND ITS DEVELOPMENT**

C. A. Elliott 1980 48 p Original contains color illustrations (PNR-90043) Avail: NTIS HC A03/MF A01

The design philosophy of this three shaft high bypass ratio engine is presented. Seal design and blade cooling in the high pressure turbine are delineated. Safety practices relating to critical rotating parts are outlined as follows: inspection; nondestructive and destructive testing; and manufacturing controls beginning with the forging billets. Disk failures in two engines are analyzed and performance and fuel consumption data are given.

Author (ESA)

**N81-21038#** National Aerospace Lab., Amsterdam (Netherlands). Scientific Services Div.

**INTEGRAL EQUATION METHODS FOR MULTI-ELEMENT AIRFOIL ANALYSIS AND DESIGN**

T. E. Labrujere May 1979 50 p refs Presented at Colloq. on Numerical Treatment of Integral Equations, Amsterdam, 27 Apr. 1979 (Contract NIVR-1819)

(NLR-MP-79020-U) Avail: NTIS HC A03/MF A01

A number of alternative approaches for solving the analysis problem are discussed. These approaches have in common a second order representation of both airfoil contour and doublet distribution, but are based on different integral equations. The method based on integral equations and spline representations appears promising for practical applications. An efficient optimization procedures for solving the design problem is described. All matters are illustrated with the aid of numerical results. Author (ESA)

**N81-21039#** Bristol Univ. (England). Dept. of Aeronautical Engineering.

**AN INVESTIGATION INTO THE POSSIBLE REDUCTION OF AERODYNAMIC DRAG OF A FUEL ECONOMY VEHICLE**

B.S. Thesis  
A. J. Underwood and C. Young Jun. 1980 72 p refs (BU-248) Avail: NTIS HC A04/MF A01

The drag of a low speed fuel economy vehicle was investigated with respect to changes to the body design, and the inclusion of certain add on devices. The characteristics of the unmodified and modified vehicles were determined in wind tunnel experiments. It was demonstrated that a drag coefficient of 0.28 can be obtained, representing a reduction of 55% compared with the unmodified vehicle. The results indicate that even lower drag can be achieved. Wheel and wheel/body interference drag contributed on the order of 1/3 to the total aerodynamic component. Major wheel design modifications and relocation should lead to a reduction in this contribution. Author (ESA)

**N81-21040#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Entwurfsaerodynamik.

**TENDENCIES IN THE DEVELOPMENT OF SUBSONIC TRANSPORT-AIRCRAFT UNDER SPECIAL CONSIDERATIONS OF AERODYNAMICS**

Horst Koerner Jun. 1980 63 p refs In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-705)

(DFVLR-Mitt-80-15) Avail: NTIS HC A04/MF A01

Tendencies in subsonic transport aircraft development, specifically due to progress in aerodynamics, are surveyed. Prospective wing profile designs and improved integration of body dimensions are considered, citing examples from the AIRBUS development program. Possible fuel savings through supercritical wing technology and by optimizing reduction in friction drag are also studied. Advantages to be gained by active control, particularly from adaptive wing technology, are then reviewed. As a potential

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application, an unconventional canard configuration, including transonic propellers, for an aircraft in the AIRBUS class is proposed. Author (ESA)

### N81-21041# European Space Agency, Paris (France). UNSTEADY PRESSURE MEASUREMENTS DURING STALL AND BUFFETING

Peter Bubltz Jan. 1981 49 p refs Trans. into ENGLISH of "Messung von instationaeren Druecken bei Stall u. Buffeting" Rept. DFVLR-Mitt-79-09, DFVLR, Apr. 1979 Original report in GERMAN previously announced as N80-25300 (ESA-TT-641; DFVLR-Mitt-79-09) Avail: NTIS HC A03/MF A01

The fluid dynamics of stall and buffeting and their effects on elastic structures are described. Using a generalized form of the equations of motion and applying Fourier transformation techniques, the dynamical solution and the quantities that govern it are briefly discussed. The experimental apparatus and the measurement method are described. Results from wind tunnel tests relating to the measurement of stall on a trapezoidal stalled wing with and without strakes are presented. Author (ESA)

### N81-21042# National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.

#### ON THE ROLE OF LAMINAR SEPARATION BUBBLES IN AIRFOIL LEADING EDGE STALLS

B. vandenBerg 13 Feb. 1980 22 p refs Submitted for publication (NLR-MP-80010-U) Avail: NTIS HC A02/MF A01

Bursting of the laminar separation bubble near an airfoil leading edge and turbulent boundary layer separation in the leading edge region were studied to determine the relative importance of both mechanisms for leading edge stalls. A theoretical analysis is made of the flow around symmetrical Joukowski airfoils, which suggests that turbulent layer separation in the nose region is the dominant cause of leading edge stalls, especially at higher Reynolds numbers. An analysis of measured wall shear stress data in the nose region of two modern airfoil sections, NLR airfoils 7303 and 7301, confirms this. Using a suitable parameter for indicating proximity of separation, the likelihood of turbulent boundary layer separation in the nose region is demonstrated for these two airfoil sections. Author (ESA)

### N81-21044\*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

#### RECENT PROGRESS TOWARDS PREDICTING AIRCRAFT GROUND HANDLING PERFORMANCE

Thomas J. Yager and Ellis J. White Mar. 1981 32 p refs Presented at the Aircraft Safety and Operating Probl. Conf., Hampton, Va., 5-7 Nov. 1980 Submitted for publication (NASA-TM-81952; L-14354) Avail: NTIS HC A03/MF A01 CSCL 01C

Capability implemented in simulating aircraft ground handling performance is reviewed and areas for further expansion and improvement are identified. Problems associated with providing necessary simulator input data for adequate modeling of aircraft tire/runway friction behavior are discussed and efforts to improve tire/runway friction definition, and simulator fidelity are described. Aircraft braking performance data obtained on several wet runway surfaces are compared to ground vehicle friction measurements. Research to improve methods of predicting tire friction performance are discussed. E.A.K.

### N81-21046# European Space Agency, Paris (France). FLIGHT SAFETY OF ROGALLO HANG GLIDERS. THEORETI- CAL AND EXPERIMENTAL STUDY OF THE FLIGHT ENVELOPE

Claudius LaBurthe and Simon Walden Feb. 1981 260 p refs Transl. into ENGLISH of "Etude de Securite sur des Planeurs ultra-legers de Formule Rogallo. Aerodyn. et Mecan. du Vol", ONERA, Paris Rept. ONERA-NT-1979-8, 1979 Original report in FRENCH previously announced as ESA-93845 (ESA-TT-634; ONERA-NT-1979-8) Avail: NTIS HC A12/MF A01

Two series of full scale wind tunnel tests were completed on 15 hang gliders. The results were used to calculate the basic performance and stability characteristics and to analyze the critical limitations. The problem of pitching stability was investigated in detail. Implications of the results in areas such as take off, stall, dives, and settings are discussed. Author (ESA)

### N81-21048# Electromagnetic Compatibility Analysis Center, Annapolis, Md.

#### THE SUSCEPTIBILITY OF REPRESENTATIVE TACAN AND DME EQUIPMENTS TO A PROPOSED, MLS L-BAND PRECISION DME SIGNAL FORMAT Interim Report

Stephen J. Sutton, Gary A. Chopak, George W. Imhof, and Jack Smithmyer Aug. 1980 151 p refs FAA-RD-80-90 (Contracts F19628-78-C-0006; DOT-FA70WAI-175) (AD-A096265; ECAC-PR-77-031) Avail: NTIS HC A08/MF A01 CSCL 17/7

Measured data are presented that show the susceptibility of representative Tactical Air Navigation/Distance Measurement Equipments (TACAN/DME) to the proposed, Microwave Landing System (MLS) L-Band Precision DME (PDME) signal format. The interrogator data are examined to determine the most susceptible equipments, and the desired and undesired signal relationships that permit range and azimuth acquisition. Comments are made on the transponder data. GRA

### N81-21049# Comsis Corp., Mountain View, Calif.

#### ARTS 2 ENHANCEMENT DESIGN ALTERNATIVE STUDY Final Report, Apr. - Dec. 1980

M. Tashker, C. Isberg, N. Savage, and M. Bell Dec. 1980 88 p (Contract DTFA-01-80-Y-10510) (AD-A096276; CASS-MV-80-02; FAA-RD-81-7) Avail: NTIS HC A05/MF A01 CSCL 17/7

This report documents a study on an enhanced ARTS 2, to be known as ARTS 2A. ARTS 2A will include the following features: beacon tracking, minimum safe altitude warning (MSAW), conflict alert, and training target generator (TTG). In addition, it will be compatible with various sensors and displays now under development, such as ASR-9, Direct Address Beacon System (DABS), and Tower Cab Digital Display (TCDD). The study considered the current capacity (memory and speed) of the ARTS 2 computer as well as the requirements for the near-term enhancements. Various computer configurations were investigated for cost, ease of system development, implementation, and installation. A recommendation is made that the current ARTS 2 computer be replaced with an LSI-2/40, a product of computer automation Irvine, California. GRA

### N81-21050# Federal Aviation Administration, Washington, D.C. Systems Research and Development Service.

#### SRDS TECHNICAL PROGRAM DOCUMENT. FISCAL YEAR 1981. RESEARCH AND DEVELOPMENT APPROVED PROJECTS

Jan. 1981 121 p (AD-A096293; FAA/RD-81-3; ARD-443) Avail: NTIS HC A06/MF A01 CSCL 01/5

This Technical Program Document (TPD) contains Research and Technology sheets which reflect Systems Research and Development Service, Federal Aviation Administration, approved projects which have significant activity occurring in Fiscal Year 1981 and beyond. These sheets contain the requirement, participating organizations, specific objectives, and milestones scheduled for accomplishment. The dates identified are in effect as of the report date (1/06/81) and are subject to change. This TPD is structured according to the following Engineering and Development Programs: Radar, Beacon, Navigation, Airborne Separation Assurance, Communications, Approach and Landing Systems, Airport/Airside, Airport/Landside, En Route Control, Flight Service Station, Terminal/Tower Control, Weather, Aircraft Safety and Support. GRA

### N81-21051# Lockheed Missiles and Space Co., Palo Alto, Calif. Palo Alto Research Lab.

#### PASSIVE IMAGERY NAVIGATION Final Technical Report, 15 Sep. 1978 - 15 Dec. 1980

O. Firschein, M. J. Hannah, D. L. Milgram, and C. M. Bjorklund  
15 Dec. 1980 147 p refs  
(Contract F33615-78-C-1612; ARPA Order 3608)  
(AD-A096245; LMSC-D767313; AFWAL-TR-81-1044) Avail:  
NTIS HC A07/MF A01 CSCL 17/7

A passive navigation small, low flying aircraft using passively sensed images of the ground, is described. A stereo pair is derived from a single camera sensing the scene at two different points on the flight path. A bootstrapping approach to position determination, starting with a set of known ground points and projecting points forward from frame to frame, is described. The landmark subsystem, used to correct the calculated position of the vehicle after a number of bootstrap iterations have been performed, is an edge analysis approach that associates edges into symchains that can be matched symbolically against a reference set of symchains for a known landmark. The major components of the bootstrapping procedure, the mechanics of operation and an error analysis obtained by simulation are discussed.  
J.D.H.

**N81-21052#** Mitre Corp., McLean, Va.  
**AN UPDATE OF THE DISCRETE ADDRESS BEACON SYSTEM (DABS) ALTERNATIVES STUDY**  
Marvin E. Kay and Martin T. Pozesky Sep. 1978 141 p refs  
(Contract DOT-FA78WA-4075)  
(AD-A096264; M78-75; FAA-RD-78-121) Avail: NTIS  
HC A07/MF A01 CSCL 17/7

This document is an update of an earlier 'Study of Alternative Beacon Based Surveillance and Data Link Systems.' It is based on the numerous studies, analyses, simulations, and flight tests conducted since the original study. The document uses the findings from that large body of work to summarize the rationale that led to the selection and continued development of DABS + ATARS + BCAS as the preferred approach to improving the surveillance, air-ground communications, and the collision avoidance functions of the ATC system and provide the basis for further improvements in the automation of the ATC system. Hypothetical scenarios heavily weighted in favor of the most competitive alternative, SAB + VHF D/L + ATARS, are presented as a basis for cost comparisons. DABS + ATARS + BCAS is shown to be the most cost effective approach.  
GRA

**N81-21053#** Mitre Corp., McLean, Va. Metrek Div.  
**RESULTS OF AN ACTIVE BEACON COLLISION AVOIDANCE EXPERIMENT CONDUCTED IN THE LOS ANGELES AIRSPACE**

Paul M. Ebert, Leonard T. Moses, and Ned A. Spencer May 1979 122 p refs  
(AD-A096285; MTR-79W00158; FAA-RD-80-7) Avail: NTIS  
HC A06/MF A01 CSCL 01/2

The Active BCAS test bed equipment, which had been tested both at NAFEC and at Washington, D.C., was upgraded to include the Whisper-Shout technique for garble reduction and the DABS mode for high integrity BCAS-to-BCAS operation. The test bed was then flown in the environment of the Los Angeles TCA and of the Orange County Airport. A comparison was then made under various levels of traffic, and with various system features. As a result of all of the tests on the feasibility equipment, general performance results are predicted and improvements for future designs are given.  
GRA

**N81-21058#** Battelle Columbus Labs., Ohio.  
**AIRCL: A PROGRAMMED SYSTEM FOR GENERATING NC TAPES FOR AIRPLANE MODELS. USER'S MANUAL**  
Final Report  
Nuri Akgerman and C. F. Billhardt Mar. 1981 40 p refs  
(Contract NAS1-15090)  
(NASA-CR-185887) Avail: NTIS HC A03/MF A01 CSCL  
01C

A computer program is presented which calculates the cutter location file needed to machine models of airplane wings or wing-fuselage combinations on numerically controlled machine tools. Input to the program is a data file consisting of coordinates on the fuselage and wing. From this data file, the program calculates tool offsets, determines the intersection between wing and fuselage tool paths, and generates additional information

needed to machine the fuselage and/or wing. Output from the program can be post processed for use on a variety of milling machines. Information on program structure and methodology is given as well as the user's manual for implementation of the program.  
R.C.T.

**N81-21059#** General Dynamics/Fort Worth, Tex.  
**EXPERIMENTAL AND ANALYTICAL STUDY ON THE FLUTTER AND GUST RESPONSE CHARACTERISTICS OF A TORSION-FREE-WING AIRPLANE MODEL**  
Arthur C. Murphy Mar. 1981 145 p refs  
(Contract NAS1-15412)  
(NASA-CR-159283) Avail: NTIS HC A07/MF A01 CSCL  
01C

Experimental data and correlative analytical results on the flutter and gust response characteristics of a torsion-free-wing (TFW) fighter airplane model are presented. TFW consists of a combined wing/boom/canard surface and was tested with the TFW free to pivot in pitch and with the TFW locked to the fuselage. Flutter and gust response characteristics were measured in the Langley Transonic Dynamics Tunnel with the complete airplane model mounted on a cable mount system that provided a near free flying condition. Although the lowest flutter dynamic pressure was measured for the wing free configuration, it was only about 20 deg less than that for the wing locked configuration. However, no appreciable alleviation of the gust response was measured by freeing the wing.  
E.A.K.

**N81-21060#** National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.  
**CHARACTERISTICS OF FLIGHT SIMULATOR VISUAL SYSTEMS**  
Irving C. Statler, ed. Apr. 1981 89 p refs Prepared in cooperation with Army Research and Technology Labs., Moffett Field, Calif.  
(NASA-TM-81278; A-8474) Avail: NTIS HC A05/MF A01  
CSCL 01C

The physical parameters of the flight simulator visual system that characterize the system and determine its fidelity are identified and defined. The characteristics of visual simulation systems are discussed in terms of the basic categories of spatial, energy, and temporal properties corresponding to the three fundamental quantities of length, mass, and time. Each of these parameters are further addressed in relation to its effect, its appropriate units or descriptors, methods of measurement, and its use or importance to image quality.  
J.M.S.

**N81-21062#** Army Aviation Engineering Flight Activity, Edwards AFB, Calif.  
**JUH-1H ICE PHOBIC COATING ICING TESTS Final Report, Jan - Mar. 1980**  
Patrick M. Morris and Ralph Woratschek Jul. 1980 54 p refs  
(AD-A096361; USAAEFA-79-02) Avail: NTIS  
HC A04/MF A01 CSCL 01/2

Artificial tests were conducted utilizing the helicopter icing spray system (hiss) with ambient temperatures ranging from 6 to 23 C, and relative humidities of 80 to 90 percent. Natural icing tests were conducted within the ambient temperature range of 2 to 12.5 C, with liquid water contents (lwc) ranging from 0.1 to 0.32 g m/cu m. The artificial icing tests verified proper operation of the test helicopter ice protection system for use as a safety device in subsequent tests. Natural icing tests were conducted to determine the operational potential of g 661 ice phobic compound and the gather data to aid in defining icing phenomenon and ice protection equipment design requirements. Excessive equipment and man-hour requirements degrade the partiality of g661 use.  
GRA

**N81-21063#** Army Aviation Engineering Flight Activity, Edwards AFB, Calif.  
**ARTIFICIAL AND NATURAL ICING TESTS PRODUCTION UH-60A HELICOPTER Final Report, Feb. - Mar. 1980**  
Marvin L. Hanks, Larry B. Higgins, and Vernon L. Diekmann Jun. 1980 131 p refs

(AD-A096239; USAAEFA-79-19) Avail: NTIS  
HC A07/MF A01 CSCL 01/3

A limited evaluation of the production UH-60A Black Hawk anti-ice and deice systems was conducted to determine the capability to operate safely in a moderate icing environment. Artificial and natural icing tests were conducted at St. Paul, Minnesota, from 11 February through 31 March 1980. Testing was performed by the United States Army Aviation Engineering Flight Activity and consisted of 27.1 productive flight hours. During these tests, three deficiencies and fourteen shortcomings were noted. The two icing related deficiencies are: failure of the droop stops to return to the shutdown position after ice accumulation on the main rotor head and failure of the anti-flapping restrainers to return to the shutdown position after ice accumulation on the main rotor head. GRA

**N81-21065#** Aeronautical Research Labs., Melbourne (Australia).  
**R.A.N. SEA KING CABIN ENVIRONMENT SURVEY.**  
**PART 2: MEASUREMENT OF TEMPERATURE AND HUMIDITY**

B. Rebbechi and D. H. Edwards Nov. 1979 19 p refs  
(AD-A096329; ARL/MECH-ENG-NOTE-377; AR-001-777)  
Avail: NTIS HC A02/MF A01 CSCL 01/3

Measurements of temperature and humidity have been made in a Royal Australian Navy Sea King over a period of four months. These measurements were carried out as part of a survey of the cabin environment which had been reported to be sufficiently adverse to cause impairment of crew efficiency, even when operating in moderate ambient temperatures. This survey has shown that the cabin temperature may be up to 12 C above the outside air temperature; this temperature differential, however, tends to decrease with increasing outside air temperature. Cabin wet bulb globe temperatures reached 32.3 C in an outside air temperature of 29 C. A WBGT level of 28 C is generally accepted as the level above which crew performance decreases; this level was reached at an outside air temperature of only 19 C. It is shown that operation of the Sea King to the extreme limits of outside environment such as the humid extremes of the Australian environment, or the United States MIL-STD-210B design environment (naval operations) would be quite impracticable, as it would be physiologically very hazardous to crew members. GRA

**N81-21066#** Joint Technical Coordinating Group for Aircraft Survivability, Washington, D.C. Design Criteria and Industry Interface Subgroup.

**DIRECTORY OF AIRCRAFT SURVIVABILITY SPECIALISTS AND THEIR AFFILIATIONS**  
Dec. 1980 96 p

(AD-A096259) Avail: NTIS HC A05/MF A01 CSCL 05/2  
A directory is presented which provides a comprehensive list of aircraft nonnuclear vulnerability/survivability specialists throughout the aerospace industry. Headings of mailing addresses for mailing through official channels to persons at the government agencies are included in this directory. R.C.T.

**N81-21067#** Naval Postgraduate School, Monterey, Calif.  
**CHALLENGE FOR OPERATIONAL EXPERIENCE FEEDBACK IN AIRCRAFT DESIGN: AN AIRCRAFT DESIGN EXAMPLE**  
**M.S. Thesis**

Stanley John Sweikar, Jr. Sep. 1979 138 p refs  
(AD-A096088; NPS54-79-019) Avail: NTIS  
HC A07/MF A01 CSCL 01/3

Since the early 1960's, the Department of Defense and the air transport industry have seen a downward trend in the number of new aircraft production starts. One of the effects of fewer new development programs has been a declining level of practical design experience acquired by individual engineers in aerospace design organizations. When compared to the growing need for design experience build-up, a result of expanding technology, the situation becomes worse. To acquire needed levels of practical design experience, feedback and utilization of operational experience is becoming increasingly important. Responsive feedback systems are used by the commercial air transport industry for providing operational experience applicable to product improvement and new development programs. Feedback systems in Naval aviation provide data and information for application

primarily in areas of manpower and material management. This thesis analyzes and discusses the present situation and basic needs for operational experience feedback in aircraft design. GRA

**N81-21068#** Quanta Systems Corp., Rockville, Md.  
**STUDY OF PILOT VISUAL INFORMATION REQUIREMENTS FOR NAVY VERTICAL TAKE-OFF AND LANDING CAPABILITY DEVELOPMENT**

W. Scott Mitchell and Charles A. Douglas Lakehurst, N.J. NAEC 1 Jun. 1979 223 p refs  
(AD-A096074; NAEC-MISC-91-OR019) Avail: NTIS  
HC A10/MF A01 CSCL 01/2

This report provides a comprehensive analysis of pilot visual landing aid requirements for operation of helicopters and V/STOL aircraft from ship and shorebased sites. The report is organized into eight sections starting with this introduction which further describes the requirement, background and approach to the study. The last four sections detail the terminology used to define pilot information, data tabulated as a result of pilot surveys, and typical existing VLA configurations. The analysis of the pilot data, evaluation of existing sources and identification of deficiencies are discussed in Section II for Helicopters and Section III for the AV-8A. The conclusions of the study, performance requirements, and recommendations are described in Section 4. GRA

**N81-21069#** Syracuse Research Corp., N. Y.  
**ADVANCED COMPOSITE AIRCRAFT ELECTROMAGNETIC DESIGN AND SYNTHESIS** Interim Report, Sep. 1978 - May 1980

R. Wallenberg, G. Dike, J. Birken, J. Barrett, E. Burt, R. Harrington, R. Rudolph, and L. Widmann May 1980 286 p refs  
(Contracts N00014-78-C-0673; N00019-79-C-0172)  
(AD-A096291; NAVAIR-518-1) Avail: NTIS  
HC A13/MF A01 CSCL 01/3

The construction of aircraft, missiles and helicopters with unprotected advanced composite materials increases their electromagnetic environment vulnerability. This is further aggravated by the diminishing susceptibility of high density digital devices (LSI, VLSI, and VHSIC) which are being utilized in the digital control systems. This study quantifies the threat to different devices in different composite airframes. It shows which composite materials exhibit the least vulnerability and initiates trade-offs to compensate it. Thin metal coatings are shown to significantly improve this with very small weight penalties for aluminum coatings. The use of coatings offers other desirable spin-offs, one being simple design composite structural joints exhibiting low electromagnetic vulnerability. GRA

**N81-21070#** Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio. Human Engineering Div.  
**AIRCRAFT TRANSPARENCY OPTICAL QUALITY: NEW METHODS OF MEASUREMENT**

Louis V. Genco and Harry L. Task Feb. 1981 31 p refs  
(AF Proj. 7184)  
(AD-A096183; AFAMRL-TR-81-21) Avail: NTIS  
HC A03/MF A01 CSCL 01/3

This report describes some traditional methods of measuring distortion in aircraft transparencies. A more expedient means of interpreting photographic distortion data via computerized digital analysis of the photo is also described. Finally, two new devices are introduced: one that measures angular deviation with extreme accuracy in a relatively small space and one that brings laboratory accuracy to field optical measurements. These latter devices employ state-of-the-art components and knowledge to provide extreme accuracy and usefulness. GRA

**N81-21071#** General Accounting Office, Washington, D. C.  
**Mission Analysis and Acquisition Div.**  
**REVIEW OF AIR FORCE'S NEXT GENERATION TRAINER AIRCRAFT PROGRAM** DEPARTMENT OF DEFENSE

9 Feb. 1981 30 p  
(AD-A096238; GAO/MASAD-81-2) Avail: NTIS  
HC A03/MF A01 CSCL 01/3

The Air Force's original plans effectively eliminated the Navy's current primary trainer aircraft, the T-34C, from consideration as



its new primary trainer aircraft. GAO believes this elimination is inconsistent with OMB Circular A-109. This inconsistency has, however, been negated by recent congressional direction for the Air Force to evaluate the T-34C as an alternative. The Air Force could use the T-34V as its primary trainer. It does not, however, perform as well as the current primary trainer or well enough to meet the stated requirements for the new primary trainer. The relative cost effectiveness of various alternatives, including the T-34C is uncertain. One analysis prepared by a consultant for the Air Force showed that the T-34C would be the least costly alternative for the primary phase of the Air Force's undergraduate pilot training program, but would be the most costly alternative if the total program were considered. Uncertainty exists regarding some assumptions and cost data in the analysis. The Air Force is also considering a service life extension of its current primary trainer as an alternative to a new acquisition. GRA

**N81-21072#** General Accounting Office, Washington, D. C. Mission Analysis and Acquisition Div.

**AIR FORCE AND NAVY PLANS TO ACQUIRE TRAINER AIRCRAFT**

28 Feb. 1981 40 p  
(AD-A096237; GAO/MASAD-81-11) Avail: NTIS HC A03/MF A01 CSCL 01/3

The Air Force and Navy plan to acquire four different aircraft for training missions. Total costs are expected to be several billion dollars. With one exception, the Air Force Next Generation Trainer and the Navy Undergraduate Jet Flight Training System acquisition programs are generally being conducted in accordance with Office of Management and Budget Circular A-109. The exception was that the requests for proposals/quotations for each program were too restrictive and precluded consideration of potential alternative solutions. Congressional interest and direction have been toward common aircraft for both the primary and advanced phases of the Navy and Air Force undergraduate pilot training programs. However, Air Force officials now believe there is little likelihood that the Air Force will use the Navy's advanced trainer aircraft. The Navy's use of the Air Force's primary trainer is also uncertain. GAO believes the Congress should explore the matter further with Defense. GRA

**N81-21074#** Messerschmidt-Boelkow G.m.b.H., Munich (West Germany).

**STUDY OF OSCILLATORY AND FLIGHT DYNAMIC BEHAVIOR OF HELICOPTERS IN ATMOSPHERIC TURBULENCE**

H. Dahl and D. Weger Bonn Bundesminister der Verteidigung 1980 72 p refs In GERMAN; ENGLISH summary Sponsored by Bundesminister der Verteidigung (BMVG-FBWT-80-4) Avail: NTIS HC A04/MF A01

A statistical model was developed which takes the nonuniform nature of the gust velocity distribution into account together with the dynamic transient oscillation of the rotor blades. Because gust effects depend strongly on the helicopter's control behavior, an analytic pilot function is included in the considerations. Hingeless and hinged rotor systems are compared. Physiological factors and data acquisition are also discussed. The results enable gust reduction systems to be incorporated in the design of helicopters. Author (ESA)

**N81-21076#** Naval Postgraduate School, Monterey, Calif.

**LOW-RANGE AIRSPEED SENSORS M.S. Thesis**

Ralph E. Duncan Dec. 1980 99 p refs  
(AD-A096359) Avail: NTIS HC A05/MF A01 CSCL 14/2

The work reported herein is comprised of two parts: A critical assessment of the existing low airspeed sensors for helicopters and V/STOL aircraft and the development of two-dimensional jet-interaction velocity sensors. The theory of operation, system description, associated electronics, advantages and disadvantages, and the development stage of the existing sensors (pitot-static system, optical convolution velocimeter, low-range orthogonal airspeed system, omnidirectional low-range airspeed sensor, swivelling probe air data system, and the fluidic velocity sensor) have been critically discussed. The need to develop a low-airspeed sensor with no moving parts and a relatively linear sensitivity

throughout the operating range and without excessive electronic amplification of the pressure signal led to the exploration of the jet-interaction principle. This culminated in the development of a two-dimensional sensor with extremely encouraging results. Continued design and development will be required to bring the jet-interaction sensor to the point of field tests with helicopters and V/STOL aircraft. GRA

**N81-21078\*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**EXHAUST EMISSION SURVEY OF AN F100 AFTERBURNING TURBOFAN ENGINE AT SIMULATED ALTITUDE FLIGHT CONDITIONS**

John E. Moss and Richard R. Cullom Mar. 1981 28 p refs  
(NASA-TM-81656; E-673) Avail: NTIS HC A03/MF A01 CSCL 21E

Emissions of carbon monoxide, total oxides of nitrogen, unburned hydrocarbons, and carbon dioxide from an F100, afterburning, two spool turbofan engine at simulated flight conditions are reported. For each flight condition emission measurements were made for two or three power levels from intermediate power (nonafterburning) through maximum afterburning. The data showed that emissions vary with flight speed, altitude, power level, and radial position across the nozzle. Carbon monoxide emissions were low for intermediate power (nonafterburning) and partial afterburning, but regions of high carbon monoxide were present downstream of the flame holder at maximum afterburning. Unburned hydrocarbon emissions were low for most of the simulated flight conditions. The local NOX concentrations and their variability with power level increased with increasing flight Mach number at constant altitude, and decreased with increasing altitude at constant Mach number. Carbon dioxide emissions were proportional to local fuel air ratio for all conditions. Author

**N81-21079\*#** Lockheed-California Co., Burbank. **AERODYNAMIC AND ACOUSTIC BEHAVIOR OF A YF-12 INLET AT STATIC CONDITIONS Final Report**

Louis H. Bangert, Edward P. Feltz, Larry A. Godby, and L. Dean Miller Jan. 1981 431 p refs Sponsored by NASA  
(NASA-CR-163106; LR-29623) Avail: NTIS HC A19/MF A01 CSCL 21E

An aeroacoustic test program to determine the cause of YF-12 inlet noise suppression was performed with a YF-12 aircraft at ground static conditions. Data obtained over a wide range of engine speeds and inlet configurations are reported. Acoustic measurements were made in the far field and aerodynamic and acoustic measurements were made inside the inlet. The J-58 test engine was removed from the aircraft and tested separately with a bellmouth inlet. The far field noise level was significantly lower for the YF-12 inlet than for the bellmouth inlet at engine speeds above 5500 rpm. There was no evidence that noise suppression was caused by flow choking. Multiple pure tones were reduced and the spectral peak near the blade passing frequency disappeared in the region of the spike support struts at engine speeds between 6000 and 6600 rpm. J.D.H.

**N81-21083\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**FLYING-QUALITIES CRITERIA FOR WINGS-LEVEL-TURN MANEUVERING DURING AN AIR-TO-GROUND WEAPON DELIVERY TASK Final Report**

Robert I. Sammonds and John W. Bunnell (AFWAL) Apr. 1981 96 p refs  
(NASA-TM-81266; A-8481) Avail: NTIS HC A05/MF A01 CSCL 01C

A moving base simulator experiment demonstrated that a wings-level-turn control mode improved flying qualities for air to ground weapon delivery compared with those of a conventionally controlled aircraft. Evaluations of criteria for dynamic response for this system have shown that pilot ratings correlate well on the basis of equivalent time constant of the initial response. Ranges of this time constant, as well as digital system transport delays and lateral acceleration control authorities that encompassed level 1 through 3 handling qualities, were determined. E.A.K.

**N81-21084\*** Blanchard (W. S., Jr.), Hampton, Va.  
**A FLIGHT INVESTIGATION OF THE ULTRA-DEEP-STALL DESCENT AND SPIN RECOVERY CHARACTERISTICS OF A 1/6 SCALE RADIOCONTROLLED MODEL OF THE PIPER PA38 TOMAHAWK Final Report**  
 W. S. Blanchard, Jr. Mar. 1981 10 p refs.  
 (NASA Order P-74271)  
 (NASA-CR-156871) Avail: NTIS HC A02/MF A01 CSCL 01C

Ultra-deep stall descent and spin recovery characteristics of a 1/6 scale radio controlled model of the Piper PA38 Tomahawk aircraft was investigated. It was shown that the full scale PA38 is a suitable aircraft for conducting ultra-deep stall research. Spin recovery was accomplished satisfactorily by entry to the ultra-deep stall mode, followed by the exit from the ultra-deep stall mode. It is concluded that since the PA38 has excellent spin recovery characteristics using normal recovery techniques (opposite rudder and forward control column pressure), recovery using ultra-deep stall would be beneficial only if the pilot suffered from disorientation. E.A.K.

**N81-21085#** Textron Bell Helicopter, Fort Worth, Tex.  
**FLY-BY-WIRE VERSUS DUAL MECHANICAL CONTROLS FOR THE ADVANCED SCOUT HELICOPTER: QUANTITATIVE COMPARISON Final Report**  
 Gaylord W. Carlock and Kenneth F. Guinn Jan. 1981 168 p refs  
 (Contract DAAK51-79-C-0007; DA Proj. 1X4-64203-D-281)  
 (AD-A096089; USAAVRADCOM-TR-80-D-10) Avail: NTIS HC A08/MF A01 CSCL 01/3

A preliminary design study comparing fly-by-wire with dual mechanical controls for the Advanced Scout Helicopter was conducted by Bell Helicopter Textron. The purpose was to determine if significant payoffs were available in the utilization of fly-by-wire design concepts. Considered were flight safety and mission reliability; vulnerability; system reliability, availability, and maintainability; control system weight; electrical and hydraulic power supply requirements; initial and life-cycle costs; and predicted handling qualities. In addition, the study investigated the payoffs from the use of innovative thinking relative to cockpit controls. GRA

**N81-21086\*** Computer Sciences Corp., Mountain View, Calif.  
**OPTICAL FIBER ILLUMINATION SYSTEM FOR VISUAL FLIGHT SIMULATION Final Report**  
 Richard H. Holow Washington NASA Apr. 1981 24 p refs  
 (Contract NAS2-9741)  
 (NASA-CR-3409) Avail: NTIS HC A02/MF A01 CSCL 01E

An electronically controlled lighting system simulating runway, aircraft carrier, and landing aid lights for flight simulations is described. The various colored lights that would be visible to a pilot by day, at dusk, or at night are duplicated at the distances the lights would normally become visible. Plastic optical fiber illuminators using tungsten halogen lights are distributed behind the model. The tips of the fibers of illuminators simulating runway lights are bevelled in order that they may be seen from long distances and at low angles. Fibers representing taxiway lights are pointed and polished for omni-directional visibility. The electronic intensity controls, which can be operated either manually or remotely, regulate the intensity of the lights to simulate changes in distance. A dichroic mirror, infrared filter system is used to maintain color integrity. J.D.H.

**N81-21087\*** Southampton Univ. (England).  
**MODEL AND BOUNDARY AERODYNAMIC DATA FROM HIGH BLOCKAGE TWO-DIMENSIONAL AIRFOIL TESTS IN A SHALLOW UNSTREAMLINED TRANSONIC FLEXIBLE WALLED TEST SECTION Semiannual Progress Report, period ending Oct. 1980**  
 S. W. D. Wolf and M. J. Goodyer Apr. 1981 92 p refs  
 (Grant NSG-7172)  
 (NASA-CR-165685) Avail: NTIS HC A05/MF A01 CSCL 14B

Data for a NACA 0012-64 airfoil at Mach numbers of 0.3, 0.5, and 0.7 with the test section flexible walls set in the 'straight' position are presented because they may prove useful in the development of wind tunnel correction techniques. A.R.H.

**N81-21088#** Calspan Advanced Technology Center, Buffalo, N.Y.  
**ADAPTIVE-WALL WIND-TUNNEL INVESTIGATIONS Final Technical Report, 1 Nov. 1978 - 31 Oct. 1980**  
 J. C. Erickson, Jr., C. E. Wittliff, C. Padova, and G. F. Homicz Feb. 1981 83 p refs  
 (Contract N00014-77-C-0052)  
 (AD-A096325; CALSPAN-RK-6040-A-2) Avail: NTIS HC A05/MF A01 CSCL 14/2

The results of a program of research on transonic wind tunnels with adaptive walls for eliminating wall interference are presented. A description is given of related experimental research performed at other laboratories using several alternative methods for controlling the flow. Features of the segmented plenum, perforated wall, two dimensional test section of the Calspan One foot Tunnel and the associated instrumentation for measuring the flow disturbance quantities are reviewed and necessary modifications made to the original experimental configuration are described. Details of adaptive-wall iteration experiments with a 4%-blockage NACA 0012 airfoil model are presented, particularly those at a free-stream Mach number of 0.9 and nominal angles of attack of 3, 2 and 1 deg. In these experiments, regions of supercritical flow terminated by shock waves extended to the tunnel walls. The results of the experiments indicate that successful iterations toward interference free flow conditions are achieved. For another phase of the research, conceptual design studies of a three dimensional transonic adaptive wall test section using the segmented plenum, perforated wall method of flow control are reported. Finally, numerical simulations of low speed flow within the Calspan test section, including the interaction of the transpired boundary layer at the walls with the flow over the model, are described in 'AIAA Paper No. 81-0160, which' is appended to the report. GRA

**N81-21089#** Air Force Human Resources Lab., Brooks AFB, Tex. Operations Training Div.  
**TRAINING EFFECTIVENESS OF PLATFORM MOTION: REVIEW OF MOTION RESEARCH INVOLVING THE ADVANCED SIMULATOR FOR PILOT TRAINING AND THE SIMULATOR FOR AIR-TO-AIR COMBAT Final Report**  
 Elizabeth L. Martin Feb. 1981 32 p refs  
 (AF Proj. 1123)  
 (AD-A095930; AFHRL-TR-79-51) Avail: NTIS HC A03/MF A01 CSCL 05/9

This report presents a summary review of the transfer-of-training studies conducted by the Operations Training Division of the Air Force Human Resources Laboratory investigating the training effectiveness of six-degrees-of-freedom platform motion cueing. A total of six studies are reviewed. Of the six studies, five were conducted on the Advanced Simulator for Pilot Training (ASPT) located at Williams AFB and one on the Simulator for Air-to-Air Combat (SAAC) located at Luke AFB. Tasks investigated included basic and advanced contact, instruments, basic fighter maneuvers, and conventional weapons delivery. The review of each study contains a statement of objectives, a summary of the method and results, a data excerpt representative of the findings, and a critique. The report also contains a description of the research strategy from which the studies were derived, a discussion of transfer-of-training methodology, and a discussion of the relationship between the results of these six studies and research findings from other agencies or facilities. Implications for future research are discussed. GRA

**N81-21131#** Boeing Commercial Airplane Co., Seattle, Wash.  
**THE 737 GRAPHITE COMPOSITE FLIGHT SPOILER FLIGHT SERVICE EVALUATION Annual Report, May 1979 - Apr. 1980**  
 Daniel J. Hoffman Nov. 1980 45 p refs  
 (Contract NAS1-11688)  
 (NASA-CR-159362; AR-6) Avail: NTIS HC A03/MF A01 CSCL 11D

Tests of removed spoilers after the sixth year of service continue to indicate modest changes in composite strength properties. Two spoilers were tested after 6 years of service, and both had residual strengths that fell within the original static strength scatter band. Both of these units had typical service

included discrepancies when tested. Based on visual, ultrasonic, and destructive inspection there continues to be no evidence of moisture migration into the honeycomb core and no core corrosion in the deployed units. The 2 year task to gather in flight moisture absorption data was completed this past year. Data are now available from these exterior mounted specimens that had been deployed on three of the participating airlines. The coupons show rational weight trends. A.R.H.

**N81-21165# Southwest Research Inst., San Antonio, Tex.  
ANALYTICAL PROCEDURES FOR CHARACTERIZING  
UNREGULATED EMISSIONS FROM VEHICLES USING  
MIDDLE-DISTILLATE FUELS Interim Report**

Lawrence R. Smith, Mary E. Parness, E. Robert Fanick, and Harry E. Dietzmann Apr. 1980 507 p refs  
(Contract EPA-68-02-2497)

(PB81-136186; EPA-600/2-80-068) Avail: NTIS  
HC A22/MF A01 CSCL 07D

Methods of collection and analysis for aldehydes and ketones, for hydrogen cyanide, and cyanogen, for hydrogen sulfide, carbonyl sulfide and organic sulfides, for ammonia and amines, for nitrous oxide, sulfur dioxide, individual hydrocarbons, for soluble sulfate and N nitrosodimethylamine, benzo-a-pyrene, and phenols were studied in detail. Ten analytical procedures were developed and codified. Interference studies and proof tests in diesel engine exhaust were conducted with every procedure and the results of these experiments are reported in detail. GRA

**N81-21211\*# Pennsylvania State Univ., University Park. Dept.  
of Mechanical Engineering.**

**AN INVESTIGATION OF AIR SOLUBILITY IN JET A FUEL  
AT HIGH PRESSURES Semiannual Status Report, 1 Sep.  
1980 - 28 Feb. 1981**

G. M. Faeth Mar. 1981 26 p refs  
(Grant NsG-3306)

(NASA-CR-154170; SASR-3) Avail: NTIS HC A03/MF A01  
CSCL 21D

Problems concerned with the supercritical injection concept are discussed. Supercritical injection involves dissolving air into a fuel prior to injection. A similar effect is obtained by preheating the fuel so that a portion of the fuel flashes when its pressure is reduced. Flashing improves atomization properties and the presence of air in the primary zone of a spray flame reduces the formation of pollutants. The investigation is divided into three phases: (1) measure the solubility and density properties of fuel/gas mixtures, including Jet A/air, at pressures and correlate these results using theory; (2) investigate the atomization properties of flashing liquids, including fuel/dissolved gas systems. Determine and correlate the effect of inlet properties and injector geometry on mass flow rates, Sauter mean diameter and spray angles; (3) examine the combustion properties of flashing injection in an open burner flame, considering flame shape and soot production. S.F.

**N81-21215# Federal Aviation Administration, Atlantic City, N.J.  
WING SPILLAGE TESTS USING ANTIMISTING FUEL Final  
Report, Mar. 1979 - Nov. 1980**

Robert F. Salmon Feb. 1981 55 p refs  
(FAA Proj. 181-520-100)

(AD-A096326; FAA-CT-81-11) Avail: NTIS  
HC A04/MF A01 CSCL 21/4

Fuel spillage tests were conducted to evaluate the performance of an antimisting fuel (FM-9 with glycol/amine carrier fluid) in a simulated crash environment. The results of the tests are: (1) FM-9 when compared with neat Jet A afforded flammability protection even under test conditions which resulted in a 'fail' for the FM-9; (2) 0.3% 80 F FM-9 provided excellent fire resistance at air-shearing velocities up to 125 knots; (3) spillage rates from 20 to 60 gallons per second yielded similar results; (4) fuel temperature impacted the antimisting performance of the fuel, 47 fuel and 110 F fuel provided fire resistance at air-shearing velocities of 133 and 116 knots, respectively; (5) additive concentration affected fire resistance performance with 0.2 percent and 0.35 percent providing protection at air-shearing velocities of 99 knots and 142 knots, respectively;

(6) MK40 rockets used as an ignition source did not alter the basic fire resistance properties of the fuel; (7) the height above the ground of the fuel release point did not affect the test results; (8) the discharge orifice shape did not affect the test results; (9) engine fuel ingestion tests indicated that fuel quantity ingested was the governing factor as to whether engine surge occurs; (10) deceleration tests indicated that the safety range of FM-9 is about 30 knots higher in deceleration tests versus steady-state spillage tests. GRA

**N81-21239# Sonobond Corp., Westchester, Pa.  
ULTRASONIC COLD FORMING OF AIRCRAFT SHEET  
MATERIALS Final Report, Dec. 1978 - Nov. 1980**

Janet Devine and Philip C. Krause Army Aviation Research and Development Command Jan. 1981 62 p refs Prepared in cooperation with Hughes Helicopters

(Contract DAAG46-79-C-0001)  
(AD-A096351; RR-80-8; USAAVRADCOM-TR-81-F-3;  
AMMRC-TR-81-1) Avail: NTIS HC A04/MF A01 CSCL  
13/8

Ultrasonic forming was investigated as a means for shaping aircraft sheet materials, including titanium 6Al-4V alloy, nickel, and stainless steel AM355-CRT, into a helicopter rotor blade noscap contour. Equipment for static forming of small coupons consisted of a modified 4000 watt ultrasonic spot welder provided with specially designed punch and die sets. The titanium alloy was successfully formed to a 60 degree angle in one step with ultrasonics, but invariably cracked under static force alone. Nickel had a low enough yield strength that it could be successfully formed either with or without ultrasonics. Insufficient ultrasonic power was available to produce beneficial effect with the high-strength steel. From analogy with commercially used ultrasonic tube drawing, it was postulated that dynamic forming of long lengths of the noscap geometry could be achieved with an ultrasonic system mounted on a draw bench. It was recommended that the ultrasonic technique be considered for forming other aircraft sheet geometries, particularly involving titanium alloy. GRA

**N81-21240# California State Dept. of Transportation, Sacra-  
mento. Office of Transportation Lab.**

**FIELD EVALUATION OF INTERNALLY SEALED CONCRETE  
Final Report, 1976 - 1979**

R. J. Spring, D. R. Smith, B. F. Neal, and J. H. Woodstrom Feb. 1980 80 p refs

(Contract DOT-D-3-58)  
(PB81-130023; TL-635350; FHWA/CA/TL-80-05) Avail:  
NTIS HC A05/MF A01 CSCL 13B

Portland cement concrete containing wax beads was evaluated. Performance of the deck concrete was evaluated after a little more than three years of service. The deck was found to be badly cracked. From cores, it was determined that the cracks extended at least to the reinforcing steel, and in some cases, entirely through the 8 1/2 inch deck. It is concluded from an examination of the cracked faces of cores that cracking was probably caused by shrinkage of the fresh concrete due to some slight delay in curing. A dry wind was blowing during concrete placement, creating adverse curing conditions. GRA

**N81-21391# National Aerospace Lab., Amsterdam (Netherlands).  
Structures and Materials Div.**

**ADDITIONAL INFORMATION ABOUT FIGHTER AIRCRAFT  
LOADING STANDARD FOR FATIGUE EVALUATION  
(FALSTAFF)**

J. B. deJonge 12 Jun. 1979 13 p refs  
(NLR-TR-79056-U) Avail: NTIS HC A02/MF A01

The complete Markov matrix, plus tabulations and level crossings pertaining to the FALSTAFF sequence are presented. This provides a means for checking whether algorithms programmed for specific process computers generate this standard load sequence for the load time history in the lower wing skin near the wing root. The essential properties of the load sequence are summarized along with a method for checking the correctness of an installed FALSTAFF generator, using its successive load transitions. Author (ESA)

**N81-21677#** Tuebingen Univ. (West Germany). Astronomisches Inst.

**HORIZONTAL COMPONENTS OF THE ATMOSPHERIC ELECTRIC FIELD. STUDIES OF THE ATMOSPHERIC ELECTRIC FIELD IN VIEW OF ELECTROSTATICALLY CONTROLLED AUTOMATIC PILOT APPLICATIONS [HORIZONTALKOMPONENTEN DES LUFTELEKTRISCHEN FELDDES. UNTERSUCHUNGEN DER LUFTELEKTRISCHEN VORAUSSETZUNGEN FUER DEN EINSATZ ELEKTROSTATISCHER AUTOPILOTEN]**

H.-J. Fischer and J. Leidel Bonn Bundesmin. des Verteidigung 1980 140 p refs In GERMAN; ENGLISH summary Sponsored by Bundesmin. des Verteidigung (BMVg-FBWT-80-7) Avail: NTIS HC A07/MF A01

The feasibility of using the natural atmospheric electric fields to achieve stabilization was studied. For such applications the electric vector should be vertical or nearly vertical. Investigations into the frequency and magnitude of horizontal components were studied over several typical regions of Germany. Industrialized and heavily populated areas strongly disturbed stabilization conditions. The effects of long term variations and local perturbations such as high buildings are discussed. The latter can be avoided by flying around them. Author (ESA)

**N81-21685#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**ANALYSIS OF ATMOSPHERIC OZONE LEVELS AT COMMERCIAL AIRPLANE CRUISE ALTITUDES IN WINTER AND SPRING, 1976 - 1977**

James D. Holdeman and Gregory D. Nastrom (Control Data Corp., Minneapolis) Apr. 1981 18 p refs (Contract DOT-FA78WAI-893) (NASA-TP-1807; FAA-EE-81-1; E-468) Avail: NTIS HC A02/MF A01 CSDL 048

It was speculated that the ozone sickness experienced by some airline passengers and crew members during the winter and spring of 1976-77 were induced by abnormally high concentrations of ambient atmospheric ozone. To investigate the possibility that 1976-77 was anomalous, ozone measurements from balloons for up to 13 years and from Global Atmospheric Sampling Program (GASP) equipped aircraft for 3 years were studied. The analyses presented show that the winter and spring seasons of 1976-77 were averaged statistically, and no evidence was found to suggest that there was more than a usual variation in the frequency that commercial airplanes encountered high ambient ozone concentrations. Author

**N81-21803#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**AN APPROACH TO REAL-TIME SIMULATION USING PARALLEL PROCESSING**

Richard A. Blech and Dale J. Arpasi 1981 9 p refs Proposed for presentation at the 1981 Summer Computer Simulation Conf., Washington, D.C., 15-17 Jul. 1981; sponsored by ISA and the Soc. for Computer Simulation (NASA-TM-81731; E-787) Avail: NTIS HC A02/MF A01 CSDL 09B

A preliminary simulator design that uses a parallel computer organization to provide accuracy, portability, and low cost is presented. The hardware and software for this prototype simulator are discussed. A detailed discussion of the inter-computer data transfer mechanism is also presented. M.G.

**N81-21804#** National Communications System, Washington, D. C. Office of Technology and Standards.

**OPEN SYSTEMS INTERCONNECTION (OSI) REFERENCE MODEL (NOVEMBER 1980) ISO DRAFT PROPOSAL (DP)7498 Final Report**

George W. White Jan. 1981 107 p (AD-A096086; AD-E100407; NCS-TIB-81-1) Avail: NTIS HC A06/MF A01 CSDL 09/2

This TIB presents the latest version of the OSI Reference Model prepared by ISO/TC97/SC16. It has been prepared to inform federal agencies of the latest developments in the architectural structure of open (distributed) systems. Comments which would be beneficial to the furthering of this work are welcome. GRA

**N81-21871#** Bolt, Beranek, and Newman, Inc., Canoga Park, Calif.

**HANDBOOK OF AIRCRAFT NOISE METRICS Final Report**

Ricarda L. Bennett and Karl S. Pearsons Washington NASA Mar. 1981 221 p refs

(Contract NAS1-14611) (NASA-CR-3406; Rept-4215) Avail: NTIS HC A10/MF A01 CSDL 20A

Information is presented on 22 noise metrics that are associated with the measurement and prediction of the effects of aircraft noise. Some of the instantaneous frequency weighted sound level measures, such as A-weighted sound level, are used to provide multiple assessment of the aircraft noise level. Other multiple event metrics, such as day-night average sound level, were designed to relate sound levels measured over a period of time to subjective responses in an effort to determine compatible land uses and aid in community planning. The various measures are divided into: (1) instantaneous sound level metrics; (2) duration corrected single event metrics; (3) multiple event metrics; and (4) speech communication metrics. The scope of each measure is examined in terms of its: definition, purpose, background, relationship to other measures, calculation method, example, equipment, references, and standards. A.R.H.

**N81-21873#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**SUBJECTIVE FIELD STUDY OF RESPONSE TO IMPULSIVE HELICOPTER NOISE**

Clemans A. Powell Apr. 1981 43 p refs (NASA-TP-1833; L-14205) Avail: NTIS HC A03/MF A01 CSDL 20A

Subjects, located outdoors and indoors, judged the noisiness and other subjective noise characteristics of flyovers of two helicopters and a propeller driven airplane as part of a study of the effects of impulsiveness on the subjective response to helicopter noise. In the first experiment, the impulsive characteristics of one helicopter was controlled by varying the main rotor speed while maintaining a constant airspeed in level flight. The second experiment which utilized only the helicopters, included descent and level flight operations. The more impulsive helicopter was consistently judged less noisy than the less impulsive helicopter at equal effective perceived noise levels (EPNL). The ability of EPNL to predict noisiness was not improved by the addition of either of two proposed impulse corrections. A subjective measure of impulsiveness, however, which was not significantly related to the proposed impulse corrections, was found to improve the predictive ability of EPNL. A.R.H.

**N81-21904#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**SOURCES, CONTROL, AND EFFECTS OF NOISE FROM AIRCRAFT PROPELLERS AND ROTORS**

John S. Mixson, George C. Greene, and Thomas K. Dempsey Apr. 1981 25 p refs Presented at the 1980 NASA Aircraft Safety and Operating Probl. Conf., Hampton, Va., 5-7 Nov. 1980 Submitted for publication

(NASA-TM-81971; L-14468) Avail: NTIS HC A02/MF A01 CSDL 20A

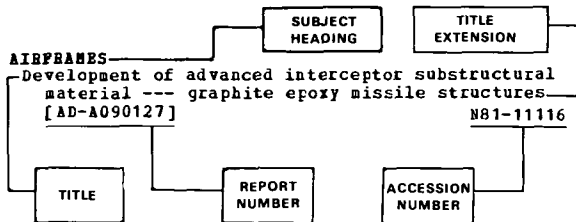
Recent NASA and NASA sponsored research on the prediction and control of propeller and rotor source noise, on the analysis and design of fuselage sidewall noise control treatments, and on the measurement and quantification of the response of passengers to aircraft noise is described. Source noise predictions are compared with measurements for conventional low speed propellers, for new high speed propellers (propfans), and for a helicopter. Results from a light aircraft demonstration program are considered which indicates that about 5 dB reduction of flyover noise can be obtained without significant performance penalty. Sidewall design studies are examined for interior noise control in light general aviation aircraft and in large transports using propfan propulsion. The weight of the added acoustic treatment is estimated and tradeoffs between weight and noise reduction are discussed. A laboratory study of passenger response to combined broadband and tonal propeller-like noise is described. Subject discomfort ratings of combined tone broadband noises are compared with ratings of broadband (boundary layer) noise alone and the relative importance of the propeller tones is examined. A.R.H.

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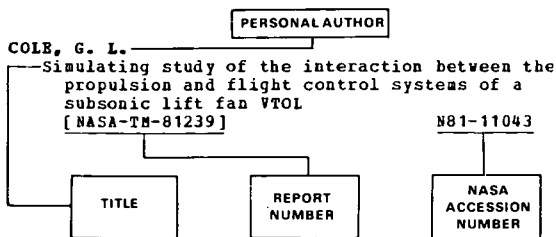
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